

**LAKES BUCHANAN AND TRAVIS  
WATER MANAGEMENT PLAN  
AND  
DROUGHT CONTINGENCY PLANS**

**SUBMITTED TO:  
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY**

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**Lower Colorado River Authority**

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# **LAKES BUCHANAN AND TRAVIS WATER MANAGEMENT PLAN**

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### **A. BACKGROUND**

The LCRA Water Management Plan is a plan for operating lakes Buchanan and Travis to help meet water needs up and down the Colorado River Basin. The plan is mandated by the 1988 Final Judgment and Decree that adjudicated (determined the extent of) the Highland Lakes water rights. Consistent with this court order, the plan was developed by LCRA and approved by the state. It is periodically updated to account for changing conditions, and each update is approved by the LCRA Board of Directors and the state, currently the Texas Commission on Environmental Quality (TCEQ).

Under the Final Judgment and Decree, LCRA was granted the right to use up to 1.5 million acre-feet of water annually from lakes Buchanan and Travis. As part of this decree, LCRA was required to determine the combined firm yield of lakes Buchanan and Travis. The combined firm yield is the amount of water the lakes can reliably provide on an annual basis even in conditions equal to the worst drought in recorded history. This water is called “firm” water. The worst drought in recorded history, for purposes of the WMP, is the drought of the 1940s to 50s known as the Drought of Record.

Water from lakes Buchanan and Travis may be available on an interruptible basis any time the actual demand for stored water under firm commitments is less than the Combined Firm Yield. Interruptible supply may be sold on an annual basis under conditions and rules set forth in this WMP. This water is called “interruptible” because this supply can be interrupted (cut back or cut off) before the availability of firm water is reduced.

The WMP is not a static document, and is periodically revised to reflect changes in firm water demands. The first WMP was approved by the state in 1989. Previous revisions were approved in 1991, 1992 and 1999. The last revision was approved by the Texas Commission on Environmental Quality (TCEQ) on Jan. 27, 2010.

The firm demands of LCRA’s municipal, industrial and other firm water customers are projected to grow significantly through 2020, which increases the likelihood of significant shortages of interruptible stored water. Because of these factors, this WMP contains significant changes to the interruptible stored water curtailment policies.

As in previous revisions, an advisory committee consisting of members representing the diverse interests that depend on lakes Buchanan and Travis provided input to LCRA related to key areas in the plan. Committee members represented municipal and industrial customers, lake area businesses and residents, farmers and the environment. The advisory committee began its work in July 2010 and worked for more than a year to reach a qualified consensus or near consensus on many of the recommended changes to the WMP. LCRA's Board of Directors considered the committee's input when it approved this WMP revision before it was sent to the TCEQ for final approval.

Out of concern for the future needs of the many areas in LCRA's 35-county water service area, including areas now using ground water supplies that are becoming depleted or are of poor water quality, the LCRA Board has reserved 50,000 acre-feet of the Combined Firm Yield.

## B. CHANGES FROM THE 2010 WATER MANAGEMENT PLAN

This WMP contains a number of policy changes from the 2010 WMP. These changes are discussed in this executive summary and in more detail in the rest of the Water Management Plan. The following is a list of some of the key changes:

- LCRA used the most recent scientific studies to develop environmental flow criteria;
- LCRA will determine applicable environmental flow criteria on two dates for different periods of the year;
- LCRA will determine the availability of interruptible stored water for the downstream irrigation operations separately for first and second crop;
- LCRA will increase the amount of interruptible stored water available for the downstream irrigation operations if combined storage in lakes Buchanan and Travis increases between Jan. 1 and March 1 for first crop or, between June 1 and Aug. 1 for second crop;
- There will be an annual cap on the total amount of interruptible stored water available for contracting in any given calendar year. LCRA will adjust the amount of interruptible stored water available for second crop to stay within the annual cap;
- LCRA will use a two-phased approach with two sets of curtailment procedures. The first set is designed for interim demands (between 2010 and 2020), and the second is designed for 2020 demands;
- In the initial years in which this WMP is in effect, LCRA will use less restrictive (interim) curtailment procedures for determining available interruptible stored water, and will shift to more restrictive curtailment procedures designed for year 2020 firm demands when specific triggers are reached (based on actual demands, water supply conditions, or a time certain);
- LCRA will stop releasing interruptible stored water for the Lakeside, Pierce Ranch and Gulf Coast irrigation operations when combined storage drops below 600,000 acre-feet whether or not the LCRA Board has declared a Drought Worse than Drought of Record; and
- The LCRA Board will have increased discretion to determine the amount of interruptible stored water available under certain severe dry weather conditions, and to determine a

potential additional amount of assumed run-of-river available to the Gulf Coast irrigation operation under certain wet forecast conditions.

Additionally, the firm yield of lakes Buchanan and Travis has reduced from 445,266 acre-feet per year to 434,549 acre-feet per year.

### C. DEMANDS

Demands on lakes Buchanan and Travis and the lower Colorado River system are many, varied and often competing. Cities, communities, industrial facilities and farmers throughout the lower Colorado River basin depend on water from lakes Buchanan and Travis and Colorado River. In addition, hydroelectric facilities, lake area businesses, recreation interests and the environment rely on the water. These demands are dynamic and continue to evolve as the region's population grows and other factors change. This could include changes in agricultural programs, new water supply strategies, and improvements in conservation, water efficiency and science that enhance our understanding of the environment's water needs.

As LCRA's primary water supply reservoirs, lakes Buchanan and Travis were designed to store water from rainfall runoff and make that water available for the various purposes described above, as well for flood control. Customers divert water directly from the reservoirs or from the river downstream of the reservoirs. The reservoir levels decline when inflows are insufficient to replenish water released, diverted or lost to evaporation and they increase when inflows exceed releases, diversions and evaporative losses. The reservoirs thus enable LCRA to serve its customers and the environment through wet and dry periods.

LCRA supplies two general categories of water from lakes Buchanan and Travis: firm and interruptible.

- **Firm water** is available through a repeat of the conditions experienced in the Drought of Record. Cities and industry, including plants that generate electricity, are the primary users of firm water, but other customers also use firm water. These include some agricultural customers, golf courses, domestic and recreation customers and others. Firm water is also used to help meet the environmental needs of the Colorado River and Matagorda Bay. The firm demands used in this WMP revision are based on the LCRA [Water Supply Resource Plan](#) (WSRP) approved by the LCRA Board of Directors in October 2010 and are described in detail in Section 2.2 (Firm Water). That plan includes demand projections through year 2100. This WMP revision, however, is designed to meet projected demands to the year 2020.
- **Interruptible water** may be curtailed (cut back) or cut off in drought. Currently, interruptible water from lakes Buchanan and Travis ("interruptible stored water") is used almost entirely for agricultural purposes in four downstream irrigation operations (LCRA's Garwood, Gulf Coast and Lakeside irrigation divisions and Pierce Ranch), and to help meet environmental flow needs below the Highland Lakes. A small amount is made available for other purposes as described in Section 4.6 (Curtailement Procedures for Interruptible Stored Water Demands Other than the Downstream Irrigation Operations).

The following table shows the demand for firm water in 2010, the projected demand in 2020 and 2030 and an interim demand level between 2010 and 2020. The projected 2030 demands are provided to show future potential growth in firm water demands. However, procedures to cut back interruptible stored water as the combined storage of lakes Travis and Buchanan decreases, known as curtailment procedures, have only been developed for demands through the year 2020 as part of this WMP revision.

### WMP Annual Firm Demand Projections

	WMP	WMP Future Projections <sup>1</sup>		
	2010	Interim	2020	2030
Firm Demands (in acre-feet per year)				
City of Austin Municipal <sup>2</sup>	182,788	193,334	203,880	232,923
LCRA Power Plants	25,866	25,866	25,866	25,866
City of Austin Power Plants <sup>2</sup>	13,500	20,851	28,202	31,502
Other Municipal & Industrial <sup>3</sup>	46,452	92,252	138,052	183,843
Other (conveyance and emergency release)	20,000	20,000	20,000	20,000
Total Firm Demand	288,606	352,303	416,000	494,134
STPNOC <sup>4</sup> Firm Back-up	20,000	20,000	40,000	40,000
Other Major Run-of-River Diverters				
Garwood - Corpus Christi	-	-	35,000	35,000
STPNOC/LCRA <sup>4</sup>	102,000	102,000	102,000	102,000
Notes:				
1. Future projections of water demands based on LCRA Water Supply Resource Plan & Region K.				
2. These customers contractually depend on run-of-river water rights with back-up (firm) water supplies from LCRA. The projected numbers reflect the total of the run-of-river water rights and the amount of contracted back-up water supplies needed from LCRA.				
3. Municipal and industrial includes other firm demands such as recreation and irrigation. Also included is domestic use around the Highland Lakes.				
4. STPNOC total diversions under run-of-river and firm back-up are limited to 102,000 acre-feet through year 2030.				

Agricultural water represents the largest demand of any user category on the LCRA system and accounted for, on average, about 70 percent of the total annual water use from 2000 to 2010. The demand for agricultural water varies from year to year based on the number of acres irrigated and weather conditions.

Currently the majority of LCRA's interruptible stored water is used for agricultural purposes downstream of the Highland Lakes in the four irrigation operations: Garwood, Gulf Coast, Lakeside and Pierce Ranch. The water is primarily used for rice farming, although turf grass, row crops, hay, pasture, aquaculture and wildlife management also use interruptible stored water.



The supply used to meet agricultural demand at the four irrigation operations is made up of interruptible stored water from lakes Buchanan and Travis and water from LCRA's run-of-river water rights. To the extent that water is available under these run-of-river rights, LCRA does not have to release stored water from lakes Buchanan and Travis. However, run-of-river water (whether originating above or below the lakes) is often unreliable or insufficient to meet the agricultural needs.

Forecasts by the Texas Water Development Board show that agricultural diversions by the downstream irrigation operations will decrease over time. The following table shows agricultural water diversions in 2010, the interim phase (which are the same as 2010) and projected diversions in 2020 and 2030.

**Projected Annual Diversions by Irrigation Operation**

Year	Irrigation Operation				
	Garwood (a-f/yr)	Lakeside (a-f/yr)	Gulf Coast (a-f/yr)	Pierce Ranch (a-f/yr)	Total (a-f/yr)
2010	92,400	139,700	178,700	27,700	438,500
Interim	92,400	139,700	178,700	27,700	438,500
2020	89,700	135,500	147,400	27,000	399,600
2030	87,100	131,300	116,100	26,200	360,700

#### D. WATER AVAILABILITY MODELING

LCRA developed three Water Availability Models for this WMP revision. A Water Availability Model, or WAM, is a computer model that simulates how much water is available under different scenarios and different management alternatives. The models use historic streamflow data, hydrology and climatic conditions to calculate the supply of available surface water.

During the last WMP revision process, LCRA used a model that simulated the operations of lakes Buchanan and Travis and major water rights downstream of the lakes using hydrologic data from 1941-1965. That model used inflows to the lakes derived from some of the first WAMs developed by the predecessor agencies of the TCEQ in the 1970s and 1980s.

For this WMP revision process, LCRA modified the most current version of TCEQ's WAM to include the most recent historic data, including the recent intense droughts experienced in 1999-2009. The hydrologic period of record in the WAM used for this WMP is 1940-2009.

#### E. ALLOCATION OF INTERRUPTIBLE SUPPLIES

One of the fundamental aspects of the WMP is to determine when and how to cut back the available supply of interruptible stored water as needed to protect firm water demands through a repeat of the Drought of Record. The WMP uses trigger levels that correspond with the combined storage of lakes Travis and Buchanan. The WMP uses those triggers to determine how much supply LCRA will make available to help meet:

- Agricultural (irrigation) demands in the four downstream irrigation operations;
- A range of freshwater inflow levels for Matagorda Bay;
- A range of instream flow levels for the Colorado River downstream of the Highland Lakes;
- Demands for a small category of interruptible users, other than the downstream irrigation operations.

The needs of downstream agricultural customers (mainly rice farmers) are supplied with a combination of the available run-of-river water and interruptible stored water from lakes Buchanan and Travis. The demand for such water can be particularly high during drier conditions.

The firm demands of LCRA's municipal and industrial customers are projected to grow significantly through 2020, which increases the likelihood of significant shortages of interruptible stored water. When determining available interruptible stored water supplies, it is essential that firm water demands be protected through a repeat of the Drought of Record. The curtailment procedures in this WMP are designed to ensure supply is available to meet projected firm demands through the year 2020 under a repeat of the hydrologic period of record (1940-2009) which includes a repeat of the Drought of Record and the short-term intense droughts the region has recently experienced.

This WMP revision includes a number of significant changes in procedures used to allocate interruptible stored water for agricultural use in the four downstream irrigation operations and to other customers, and in the criteria used to allocate water for the environmental needs of the Colorado River and Matagorda Bay. These changes allow LCRA to be more responsive to changes in water supply conditions. A list of key changes can be found in Section B of this executive summary and discussion of some of the key changes that deal with interruptible water follows. As with recent WMPs, evaluation of demands and the curtailment of interruptible stored water for Garwood and Pierce Ranch will be accomplished pursuant to the terms of specific agreements related to the supply of interruptible water to those operations.

#### Separate curtailment procedures

This WMP revision is designed to protect projected increases in firm demands through 2020 through a repeat of the Drought of Record. However, to make the WMP more adaptive to actual firm demands and demand growth, LCRA has developed two separate sets of curtailment procedures for interruptible stored water and environmental flow criteria. The first "interim" set applies immediately, and the second set will apply when certain conditions are met. By creating two sets of curtailment procedures and a mechanism for shifting between the two, this WMP allows LCRA to be more adaptive. More interruptible stored water would be provided in the initial years and more restrictive curtailment procedures could be implemented over time.

The interim demand phase curtailment procedures are in effect immediately upon the effective date of this WMP revision. The LCRA Board will determine whether to shift to the second set of curtailment procedures, the 2020 curtailment procedures, after opportunity for public comment

and in accordance with specific criteria. The shift to 2020 curtailment procedures would be effective for the next calendar year if the LCRA Board finds that certain defined criteria (based on a combination of actual and projected demands or other factors) are met. These criteria are more fully described in Section 4.2 (Process for Determining Applicable Curtailment Procedures).

#### Separate determination for first and second crop

Previous versions of the WMP based the decision of how much interruptible stored water was available for the four downstream irrigation operations on the Jan. 1 combined storage level of lakes Buchanan and Travis. This WMP has a separate process for determining availability of water for first and second crop. First crop availability will be based on Jan. 1 combined storage, with the possibility of increasing the supply of interruptible stored water if combined storage is higher on March 1. Second crop availability will be based on June 1 combined storage, with the possibility of increasing the supply of interruptible stored water if combined storage is higher on Aug. 1.

#### Annual limit on interruptible stored water

Under this WMP, the amount of interruptible stored water made available for diversions in any given year to the four downstream irrigation operations will be limited even when storage levels in lakes Buchanan and Travis are relatively high or near full. On an annual basis, no more than 273,500 acre-feet per year of interruptible stored water will be available for diversion for first and second crop during the interim demand phase, and no more than 249,000 acre-feet per year of interruptible stored water would be available for diversion during the 2020 demand phase. Water available for contracting for second crop water will be limited as necessary to stay within the annual cap.

#### Helping meet environmental flow needs

Under this WMP, as in past WMPs, a combination of firm and interruptible stored water is provided to help meet environmental flow needs. For this WMP, LCRA continues to commit 33,440 acre-feet per year of its firm supply from lakes Buchanan and Travis for environmental flow purposes.

This WMP has been updated to reflect the most recent studies on the environmental flow needs of the Colorado River and Matagorda Bay. The criteria include additional levels of flow targets, and changes to the seasonality. The triggers LCRA follows for providing water for environmental flows are based on the combined storage of lakes Travis and Buchanan. In prior WMPs, the criteria were based on the Jan. 1 combined storage. In this WMP, the environmental flow criteria in place from March through June are based on the combined storage on Jan. 1, and the environmental flow criteria in place from July through the following February are based on the combined storage on June 1.

## F. RIVER OPERATIONS

LCRA operates the Colorado River and the Highland Lakes as a system to efficiently manage water supply and mitigate flood damage. To accomplish this goal, LCRA uses a number of tools and practices that it regularly updates.

LCRA maintains and operates a Hydro-meteorological Data Acquisition System (Hydromet) of about 265 gauges located throughout the lower Colorado River basin. The Hydromet gauges send water levels, rainfall and other weather data to LCRA computers every 15 minutes. LCRA also receives data from 12 gauges that the USGS operates cooperatively with other agencies and shares Hydromet data with the National Weather Service West Gulf Coast River Forecast Center in Fort Worth, Texas (RFC).

LCRA develops and maintains computer systems and protocols to collect data from its reservoirs and pump stations and to communicate with major water users that operate reservoirs, pump stations and wastewater treatment plants that contribute significant amounts of return flows to the Colorado River below Mansfield Dam. Data on expected and actual storage, diversions and return flows is used to plan daily water supply operations, to coordinate pumping operations and to report on water use.

LCRA has also developed a suite of computer models to perform the following functions:

- Estimate the amount of flows entering the Colorado River;
- Evaluate the routing or timing and attenuation of flows released from the Highland Lakes to the lower Colorado River;
- Determine the necessary releases of stored water and pass-through of run-of-river flows to meet downstream demands;
- Schedule daily releases from dams; and
- Allocate releases and diversions for users to the appropriate source of supply (run-of-river or stored water) based on water rights priority.

## G. GLOSSARY

To understand the Water Management Plan, it is important to know the definitions of the key legal and hydrologic terms used in this plan. The major terms are defined below and should be considered specific to LCRA's WMP.

**adjudication** - a court proceeding to determine all rights to the use of water on a particular stream system.

**agricultural** - any of the following uses or activities involving agriculture, including irrigation:

- cultivating the soil to produce crops for human food, animal feed, or planting seed or for the production of fibers;
- the practice of floriculture, viticulture, silviculture, and horticulture, including the cultivation of plants in containers or nonsoil media by a nursery grower;

- raising, feeding, or keeping animals for breeding purposes or for the production of food or fiber, leather, pelts, or other tangible products having a commercial value;
- raising or keeping equine animals;
- wildlife management;
- planting cover crops, including cover crops cultivated for transplantation, or leaving land idle for the purpose of participating in any governmental program or normal crop or livestock rotation procedure; and
- aquaculture.

**attenuation** - the reduction in the peak of a hydrograph, as it moves downstream, resulting in a more broad, flat hydrograph.

**beneficial use of water** - use of the amount of water that is economically necessary for a purpose authorized by law, when reasonable intelligence and reasonable diligence are used in applying the water to that purpose.

**combined firm yield** - the calculated firm yield of lakes Buchanan and Travis when operated as a system. See “firm yield” definition below.

**curtail (water)** - to reduce the supply of water being provided.

**cutoff (water)** - to discontinue, or to terminate completely, the supply of water that would otherwise be provided.

**domestic water use** –use of water by an individual or a household to support domestic activity. Such use may include water for drinking, washing, or culinary purposes; for irrigation of lawns, or of a family garden and/or orchard; for watering of domestic animals; and for water recreation including aquatic and wildlife enjoyment, but does not include water used to support activities for which consideration is given or received or for which the product of the activity is sold.

**drawdown** - the lowering of the water level in a water body by diversion, pumping, release, evaporation, or other losses.

**drought** - a period of below average rainfall and/or runoff that impacts streamflow and has the potential to impact water supplies.

**drought contingency plan (DCP)** – a plan required by the Texas Commission on Environmental Quality that outlines drought response measures to be taken in response to specific drought conditions.

**Drought of Record (DOR)** - the worst hydrologic drought for which streamflow records are available.

**firm water** - a supply of water that is to be made available without shortage through a repeat of the Drought of Record.

**firm yield** - that amount of water, that the reservoir could have produced annually if it had been in place during the worst drought of record. In performing this simulation, naturalized streamflows will be modified as appropriate to account for the full exercise of upstream senior water rights is assumed as well as the passage of sufficient water to satisfy all downstream senior water rights valued at their full authorized amounts and conditions as well as the passage of flows needed to meet all applicable permit conditions relating to instream and freshwater inflow requirements.

**gauging station** - a particular site on a stream, canal or lake where systematic observations of hydrological data are obtained.

**instream flow** - an amount of streamflow in a stream or river to support aquatic life, minimize pollution, or for recreational use.

**interim demands (firm)** - a level of demand about half-way between year 2010 and year 2020 projected demands. These demands are not an exact average of year 2010 and 2020 demands; rather they take into account the timing in which certain demands are anticipated to occur.

**interruptible stored water** - a supply of stored water that is subject to interruption, including a partial curtailment or complete cutoff.

**irrigation** - The use of water for the irrigation of crops, trees, and pasture land, including, but not limited to, golf courses and parks, which do not receive water through a municipal distribution system.

**LCRA General Manager (or General Manager)**- the General Manager of the Lower Colorado River Authority or his or her designee.

**run-of-river flows** - the flow in the river that is available under law at a given point on the river at a given point in time to honor a water right with a given priority date. Rights to use run-of-river flows for beneficial uses, rights to store inflows in reservoirs, and pass-through of inflows and releases from reservoirs, are regulated by the TCEQ.

**storable inflows** - the daily inflows to the reservoir system minus the daily pass-throughs from the reservoir system required to meet downstream senior water rights demands.

**storage capacity** - the quantity of water that can be contained in a reservoir.

**streamflow** - rate of flow of water that occurs in a natural channel.

**water conservation** - those practices, techniques and technologies that will: (1) reduce the consumption, loss or waste of water; (2) improve the efficiency in the use of water; or (3) increase the recycling and reuse of water, so that a water supply is made available for future or alternative uses.

**water right** - a legally protected right, granted by law, to impound, divert, convey, or store state water and put it to one or more beneficial uses.

**Acronyms:**

AF	acre-feet
B&E	bay and estuary
CFS	cubic feet per second
DCP	Drought Contingency Plan
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
LCRA	Lower Colorado River Authority
MAF	million acre-feet
MBHE	Matagorda Bay Health Evaluation
msl	mean sea level (or above mean sea level)
STPNOC	South Texas Project Nuclear Operating Company
TCEQ	Texas Commission on Environmental Quality
TWDB	Texas Water Development Board
USACE	U.S. Army Corps of Engineers
USGS	United States Geological Survey
WAM	Water Availability Model
WMP	Water Management Plan
WTP	Water Treatment Plant

## CHAPTER 1

### INTRODUCTION TO THE WATER MANAGEMENT PLAN

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#### 1.1 BACKGROUND

The 1988 Final Judgment and Decree<sup>1</sup> adjudicating the Lower Colorado River Authority's (LCRA's) Highland Lakes water rights required LCRA to submit a reservoir operations plan for lakes Buchanan and Travis. The plan must describe how LCRA will determine the amount of firm and interruptible stored water available for use from lakes Buchanan and Travis and how LCRA will manage the waters in lakes Buchanan and Travis and the Colorado River.

- Firm water is water that can be supplied from lakes Buchanan and Travis during a repeat of the worst drought in recorded history for the lower Colorado River basin, which is the drought of the 1940s and 50s. This drought is known as the Drought of Record.
- Interruptible stored water is water from lakes Buchanan and Travis that must be cut back or cut off during drought or times of shortage to ensure that LCRA can meet firm customer demands.

The original reservoir operations plan, referred to as the Water Management Plan (WMP), was developed by LCRA, approved by its Board of Directors, and approved by the Texas Water Commission, predecessor to the Texas Commission on Environmental Quality (TCEQ), in 1989. Since then, the WMP has been revised by LCRA and approved by the TCEQ (or its predecessors) periodically (in 1991, 1992, 1999 and 2010).

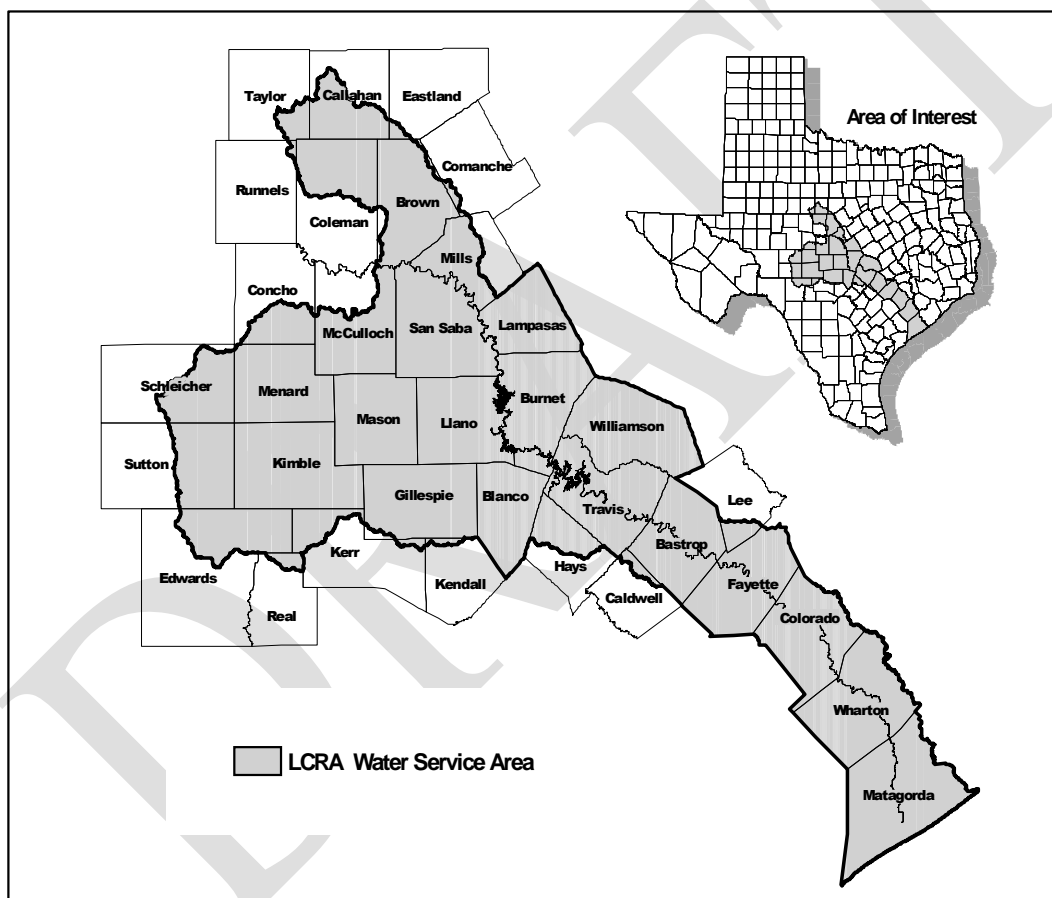
The WMP prescribes how LCRA will operate lakes Buchanan and Travis to supply water to the diverse interests in LCRA's service area (*See* Figure 1-1). Specifically, it identifies the actions LCRA will take to allocate available water supplies from the two reservoirs for its firm water customers, interruptible stored water customers, and the environment during drought and nondrought periods. Potential actions outlined in the plan include adjusting stored water available for interruptible agricultural customers and for environmental flow needs. In addition, LCRA's Drought Contingency Plan for firm customers addresses how those customers, primarily municipalities and industries, must respond to drought conditions by implementing provisions of their drought contingency plans.

Lakes Buchanan and Travis are operated as a single water supply system and are designed to supply water and address needs of varied interests within LCRA's service area, including:



- LCRA's firm water customers (primarily municipal, industrial, and electric generation facilities);
- LCRA's interruptible stored water customers (four downstream irrigation operations and other small users);
- Environmental needs to help meet instream flows in the Colorado River downstream of Austin and freshwater inflows into Matagorda Bay; and
- Recreation and economic interests on the Highland Lakes.

**Figure 1-1. LCRA Water Service Area as of January 1, 2012.**



To that end, the WMP includes procedures for making interruptible stored water available for downstream irrigation operations and other users, procedures for releasing water to help support environmental flow needs and criteria for declaring a Drought Worse than Drought of Record. The WMP also includes a calculation of the combined firm yield, which is the amount of water that can be supplied annually from lakes Buchanan and Travis through a repeat of the Drought of Record.

Revisions to the WMP are necessary to address changing conditions, including, among others, increased demands from firm customers and updated science related to environmental flows. As the actual water demands from lakes Buchanan and Travis for municipal, industrial and other firm water users continue to increase, the amount of interruptible stored water available from the lakes for agricultural use in the downstream irrigation operations and to help meet downstream environmental flows is expected to continue to decrease.

## 1.2 BASIC GOALS AND GUIDELINES FOR MANAGING LAKES BUCHANAN AND TRAVIS

The initial WMP and various revisions have been developed using the following major goals as provided in the 1988 Final Judgment and Decree:

- Lakes Buchanan and Travis and the Colorado River will be managed together as a single system for water supply purposes;
- LCRA will manage the system to maximize the beneficial use of water derived from inflows below the Highland Lakes; and
- LCRA will manage the system to stretch and conserve the water stored in lakes Buchanan and Travis.<sup>2</sup>

To achieve the goals stated above, LCRA will manage the system according to the following guidelines:

1. All demands for water from the Colorado River downstream of lakes Buchanan and Travis should be satisfied to the extent possible by run-of-river flows of the Colorado River;
2. Inflows should be passed through lakes Buchanan and Travis to honor downstream senior water rights only when those rights cannot be satisfied by the flow in the Colorado River below the Highland Lakes;
3. Water should be released from storage in lakes Buchanan and Travis to satisfy downstream demands only to the extent that such demands cannot be satisfied pursuant to run-of-river water rights;
4. Firm commitments from lakes Buchanan and Travis shall not exceed the combined firm yield of lakes Buchanan and Travis;
5. Water from lakes Buchanan and Travis may be available on an interruptible basis at any time that the actual demand for stored water under firm commitments is less than the firm yield. To the extent that a demand for water may exist on an interruptible basis, such stored water should be made available;
6. The water from lakes Buchanan and Travis available on an interruptible basis should be interrupted or curtailed to the extent necessary to allow LCRA to satisfy all existing and projected demands pursuant to firm commitments; and
7. Water shall not be released through any dam solely for hydroelectric generation, except during emergency shortages of electricity and during other times that such releases will not impair LCRA's ability to satisfy all existing and projected demands for stored water for firm and nonfirm, interruptible commitments.<sup>3</sup>

### 1.3 TEXAS COMMISSION ON ENVIRONMENTAL QUALITY JANUARY 2010 ORDER

On Jan. 27, 2010, TCEQ approved the 2010 WMP. Consistent with the order approving the revised WMP (found in Appendix C-6), LCRA began the WMP revision process in the summer of 2010. The order requires LCRA to address, at a minimum, the following issues:

1. Interruptible curtailment procedures needed to ensure that LCRA can satisfy projected firm customer demand should intense drought conditions such as those experienced over the past several decades recur;
2. An evaluation of the adequacy of the criteria for declaring a drought worse than the Drought of Record;
3. An evaluation of the minimum combined storage in lakes Buchanan and Travis necessary or appropriate to protect firm customers through a repeat of the Drought of Record or under conditions worse than the Drought of Record;
4. Incorporation of appropriate changes to reflect LCRA's agreements and obligations to South Texas Project Nuclear Operating Company (STPNOC) under the Settlement Agreement and Amended and Restated Contract, including the Water Delivery Plan;
5. LCRA's agreement with the City of Austin regarding return flows, consistent with Section VIII(C)(1) of the Settlement Agreement by and between the City of Austin and the LCRA regarding Joint Water Resource Management and the Resolution of Certain Regulatory Matters Pending at the TCEQ, dated June 18, 2007; and
6. Revisions to provisions governing the manner in which LCRA provides water from lakes Buchanan and Travis to address environmental flow needs using the best available scientific information. Such revisions shall include:
  - i. A mechanism for adjusting the manner in which LCRA provides water for environmental flow needs that addresses significant improvements in storage conditions during the course of a year;
  - ii. A mechanism for limiting harmful intra-daily fluctuations of instream flows to prevent significant adverse impacts from periods of low flows; and
  - iii. Specification, to the maximum extent reasonable, of an overall instream flow regime.<sup>4</sup>

### 1.4 INTEREST GROUPS AND ADVISORY COMMITTEE PROCESS

LCRA has used input from an advisory committee to develop every WMP. The TCEQ 2010 WMP Order required LCRA to use a revision process designed to allow meaningful participation by interested basin stakeholder groups and achieve regional consensus, where possible. For this WMP revision, LCRA again established an advisory committee to provide input to LCRA on the WMP update. The LCRA Board provided input on the composition of the 16-member advisory committee. LCRA endeavored to create a committee to represent interests within the basin; however, no committee can fully represent all interests within the basin. The committee included members from each of the major interests that depend on the Highland Lakes: firm customers (cities, industries, etc.), agriculture, environmental interests and lake area businesses and residents. Each advisory committee member also had an alternate to attend meetings and participate in the process in the event of the member's absence.

Over more than 12 months, LCRA hosted 20 formal advisory group meetings, (which were often all-day meetings) as well as several more informal meetings with smaller contingents of the advisory committee. Attendance was greater than 90 percent throughout the advisory committee process. There was extensive dialogue among the interests to educate one another about how and why water is important to each interest. Committee members and their alternates spent a great amount of time, energy and effort learning about and discussing key issues. Most important, the advisory committee provided LCRA staff with input on key areas. Meeting summaries were distributed to the committee, and updates were regularly provided to the LCRA Board and members of the public. Throughout the process, LCRA staff worked hard to provide the committee with the best available information on the issues as members worked toward consensus. From the beginning of the process, consensus was defined by the committee as:

“All agree that their major interests have been considered and factored in a manner that they can generally support even if all their interests have not been fully satisfied.”

The committee spent several months towards the end of the 12-month process addressing key issues such as the availability of interruptible water for irrigated agriculture and associated curtailment triggers and procedures. Much time was spent evaluating many computer simulations to get an understanding of how various changes in curtailment triggers and procedures would change key results or affect their interests.

The advisory committee was able to reach full consensus from all members on all items for which the staff sought consensus except for one. For that one item, the curtailment triggers and procedures for meeting the 2020 level of demands, the representative from the Gulf Coast Irrigation Operation was not able to agree with the rest of the group. Additionally, the lake interests requested that their position on consensus be registered as “qualified.”

Following the initial 12-month process, LCRA staff continued to work with the advisory committee on two potential exceptions to the standard curtailment procedures identified in the plan, one for extremely dry conditions, and one for wetter than normal conditions. The committee was able to reach a qualified consensus on these two items.

Throughout the process, the advisory committee thus provided key input as LCRA developed the recommended changes reflected in this WMP revision. LCRA wishes to thank the committee members for their input and for their many hours spent working together to help shape many of the provisions in this update to the WMP.

#### 1.4.1 Firm customers

Firm customers were represented by the following entities:  
(Committee members are listed first, followed by their alternates)

- City of Austin: Greg Meszaros and Teresa Lutes;
- City of Burnet: David Vaughn and Crista Bromley;
- Lakeway Municipal Utility District: Earl Foster and George Russell (City of Marble)

- Falls);
- Horseshoe Bay Resort: Ken Gorzycki and Roger Goettsch (Barton Creek Resort and Club);
- South Texas Project Nuclear Operating Company: Rick Gangluff and Sandra Dannhardt.

#### 1.4.2 Agricultural customers

Agricultural customers were represented by the following irrigation entities:

- Garwood Irrigation Division: Ralph Savino and Jeff Dugie;
- Gulf Coast Irrigation Division: Haskell Simon and GW Franzen;
- Lakeside Irrigation Division: Robby Cook and Ronald Gertson;
- Pierce Ranch: Laurance Armour and Joe Mike Crain.

#### 1.4.3 Environmental interests

Environmental interests were represented by the following entities:

- National Wildlife Federation: Myron Hess and Steve Box (Environmental Stewardship);
- Sierra Club: Jennifer Walker and Ken Kramer;
- Texas Parks and Wildlife Department: Cindy Loeffler and David Bradsby.

#### 1.4.4 Lake interests

Lake interests were represented by the following businesses and communities:

- Lake Buchanan residential: Jo Karr Tedder and Rick Albers;
- Lake Buchanan business: Rusty Brandon and John Williams;
- Lake Travis residential: Kerry Spradley and Dorothy Taylor;
- Lake Travis business: Janet Caylor and Tom Harrison.

- 
1. Cause No. 115,414 A-1, 264th Judicial District In Re: The Exceptions of the Lower Colorado River Authority and the City of Austin to the Adjudication of Water Rights in the Lower Colorado River Segment of the Colorado River Basin
  2. Cause No. 115,414-A-1. Finding 26.
  3. Id.
  4. Agreed Order Approving Amendments to Lower Colorado River Authority's Water Management Plan, Texas Commission on Environmental Quality, Ordering Provision 1.f., Issued Jan. 27, 2010.

## CHAPTER 2 DEMANDS

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### 2.1 BACKGROUND

Demands on the Highland Lakes and the lower Colorado River system are many, varied and often competing. Cities, communities, industrial facilities and farmers throughout the lower Colorado River basin depend on water from the Highland Lakes and Colorado River. In addition, hydroelectric facilities, lake area businesses, recreation interests and the environment rely on the water. These demands are dynamic and will continue to evolve as the region's population grows and other factors change. This could include changes in agricultural programs, implementation of new water supply strategies, improvements in conservation, and new scientific studies that enhance our understanding of the environment's water needs.

LCRA's reservoir system (lakes Buchanan and Travis) is designed to store water from rainfall runoff and make that water available for various purposes. Water is released from the reservoirs for a number of reasons, including customer use, flood control, hydroelectric power generation and environmental needs. Customers divert water directly from the reservoirs or from the river downstream of the reservoirs. The reservoir levels decline when inflows are insufficient to replenish water released, diverted or lost to evaporation, and increase when inflows exceed releases, diversions and evaporative losses. This system enables LCRA to serve its customers and the environment through wet and dry periods.

LCRA supplies two general categories of water from lakes Buchanan and Travis: firm and interruptible.

- Firm water is available through a repeat of the conditions experienced in the Drought of Record. Cities and industry, including power plants, are the primary users of firm water, but other customers also use firm water. These include some agricultural customers, golf courses, domestic, recreation and other users. Firm water may also be used to provide supplemental water for the environmental needs of the Colorado River and Matagorda Bay. The firm demands used in the WMP are based on the LCRA Water Supply Resource Plan<sup>1</sup> (WSRP) approved by the LCRA Board of Directors in October 2010 and are described in detail in Section 2.2.1. That plan includes demand projections through

year 2100. The WMP however is only designed to meet demands up to year 2020 projections.

- Interruptible water may be curtailed (cut back) or cut off in drought. Currently, interruptible water from lakes Buchanan and Travis (interruptible stored water) is used almost entirely for agricultural purposes in the downstream irrigation operations (LCRA's Garwood, Gulf Coast and Lakeside irrigation divisions, and Pierce Ranch), and to help meet environmental flow needs below the Highland Lakes. A small amount is made available for other purposes as described in Chapter 4.

## 2.2 FIRM WATER

### 2.2.1 Demands

Firm water demands primarily consist of municipal and industrial demands that are to be met without shortage through a repeat of the Drought of Record. A small portion of firm water is also used for irrigation, mining, domestic and recreational purposes, and LCRA has set aside a portion of its firm supply to help meet environmental needs.

Municipal use includes water used by cities, municipalities, water districts, commercial establishments, industries and institutions to the extent that such uses are included in the definition of municipal use in the rules of the Texas Commission on Environmental Quality (TCEQ).

For the purposes of the WMP, the demands of individual households that pump water directly from the lakes (domestic use) were included with municipal demands. As of January 2012, LCRA has issued a significant number of firm water contracts for domestic use. However, many of these diverters still do not have contracts with LCRA. Absent a contract, most if not all of these diverters have no legal claim to the water they are diverting. At some point, LCRA may pursue enforcement of its water rights to curtail these unauthorized diversions. Although contracts do not exist for all of the domestic water use, LCRA has included existing and projected domestic water use in the demands for this WMP revision as it did in the 2010 WMP.

Industrial demands include water for manufacturing, construction and cooling for electric generation by means other than hydrogeneration. Most of the lower Colorado's industrial users today are located downstream of the Highland Lakes.

The WSRP demand projections were based on work by the Texas Water Development Board and the Lower Colorado Regional Water Planning Group (Region K). Where appropriate, the demands were updated based on more recent growth trends and discussions with local municipal and industrial entities. Specific assumptions related to firm water demand projections were:

1. Demands for municipal, industrial, electric power production and other needs were calculated based on the amount of water that would be needed during the Drought of Record to ensure that ample supplies would be available during a similar drought;

2. Communities and utilities that rely on groundwater, and areas where Region K projections indicate sufficient groundwater will be available through the planning period, would not require water from LCRA;
3. Water availability analyses included conservation and reuse for the City of Austin, consistent with Region K and the provisions of the 2007 Settlement Agreement between LCRA and the City of Austin;
4. Demands include the water to be provided by contract (up to 25,000 acre-feet per year) to Williamson County under the provisions of House Bill 1437;
5. Municipal demands were developed using substantiated, revised population estimates based on recent growth patterns to estimate future growth;
6. Municipal demands for each decade were calculated based on population projections using the same per capita water use approach used in the 2006 Region K plan;
7. New and pending contracts for municipal demand were included;
8. Projected demands for domestic use on the Highland Lakes was added;
9. Region K industrial demand, and new and pending contracts for industrial use were included;
10. Conveyance losses from the point of release of water from the Highland Lakes to the point of delivery for existing contracts were added; and
11. Other demands such as emergency hydro-generation were included.

The projected 2020 firm demands used in the WMP are summarized in Table 2-1. The projected 2030 demands are also provided to show future potential growth in firm water demands. However, procedures to cut back interruptible stored water as the combined storage of lakes Travis and Buchanan decreases, known as curtailment procedures, have not been developed for the 2030 demands as part of this WMP revision.

Interim firm demands representing an intermediate scenario roughly halfway between year 2010 and 2020 were developed for the WMP to make the plan more adaptive. Using an interim step, rather than shifting from a year 2010 to a year 2020 demand scenario in a single step, allows additional interruptible stored water to be made available in the near term before the year 2020 firm demands begin to materialize. The interim and year 2020 demands were used to develop the interim and year 2020 curtailment procedures for interruptible stored water presented in Chapter 4. A mechanism to shift from the interim to year 2020 curtailment procedures is also presented in Chapter 4.

#### 2.2.2 Board reservation

Out of concern for the future needs of the many areas in LCRA's 35-county water service area, including areas now using ground water supplies that are becoming depleted or are of poor water quality, the LCRA Board has reserved 50,000 acre-feet of the combined firm yield.



**Table 2-1 – WMP Firm Demand Projections**

	WMP	WMP Future Projections <sup>1</sup>		
	2010	Interim	2020	2030
Firm Demands (in acre-feet per year)				
City of Austin Municipal <sup>2</sup>	182,788	193,334	203,880	232,923
LCRA Power Plants	25,866	25,866	25,866	25,866
City of Austin Power Plants <sup>2</sup>	13,500	20,851	28,202	31,502
Other Municipal & Industrial <sup>3</sup>	46,452	92,252	138,052	183,843
Other (conveyance and emergency release)	20,000	20,000	20,000	20,000
Total Firm Demand	288,606	352,303	416,000	494,134
STPNOC <sup>4</sup> Firm Back-up	20,000	20,000	40,000	40,000
Other Major Run-of-River Diverters				
Garwood - Corpus Christi	-	-	35,000	35,000
STPNOC/LCRA <sup>4</sup>	102,000	102,000	102,000	102,000
Notes:				
1. Future projections of water demands based on LCRA Water Supply Resource Plan & Region K.				
2. These customers contractually depend on run-of-river water rights with back-up (firm) water supplies from LCRA. The projected numbers reflect the total of the run-of-river water rights and the amount of contracted back-up water supplies needed from LCRA.				
3. Municipal includes other firm demands such as recreation and irrigation. Also included is domestic use around the Highland Lakes.				
4. STPNOC total diversions under run of river and firm back-up are limited to 102,000 acre-feet through year 2030.				

### 2.3 AGRICULTURAL DEMANDS IN THE DOWNSTREAM IRRIGATION OPERATIONS

Currently the majority of LCRA's interruptible stored water is used for agricultural purposes downstream of the Highland Lakes in four irrigation operations: Garwood, Gulf Coast, Lakeside and Pierce Ranch. The water is primarily used for rice farming, although turf grass, row crops, hay, pasture, aquaculture and wildlife management also use interruptible stored water.<sup>2</sup>

Agricultural use represents the largest demand of any user category on the lower Colorado River system and accounted for, on average, about 70 percent of LCRA's total annual water use from 2000 to 2010. The demand for agricultural water varies from year to year based on the number of acres irrigated and weather conditions.

The supply used to meet agricultural demand at the four irrigation operations is made up of interruptible stored water from lakes Buchanan and Travis and LCRA's run-of-river water rights.<sup>3</sup> To the extent that water is available under these run-of-river rights, LCRA does not have to release water from storage. Run-of-river water (whether originating above or below the

Highland Lakes) is often unreliable or insufficient to meet the agricultural needs.<sup>4</sup> However, in some wet years little to no stored water is needed to meet agricultural demands.

The Texas Water Development Board (TWDB) forecasts that agricultural diversions by the downstream irrigation operations will decrease over time. (TWDB 2001<sup>5</sup> and 2006<sup>6</sup>). The 2010 Water Management Plan similarly forecast future reductions in demand. For this WMP revision, the projected agricultural demands were based on the Lower Colorado Regional Planning Group's (Region K) Regional Water Plan (TWDB, 2006). However, recent water use exceeded the Regional Water Plan's projection in 2010, particularly in the Gulf Coast operation. The agricultural demands shown in Table 2-2 reflect the Regional Water Plan's forecasted irrigation demands with adjustments for the Gulf Coast operation based on recent water use. The adjusted projected year 2010 diversions were used to develop the interim curtailment procedures and the projected year 2020 diversions were used to develop the 2020 curtailment procedures.

Table 2-2 represents demands that are expected to be exceeded only 10 percent of the time for the period of historic record and therefore represent irrigation demands during drought conditions. The period of historic record used for development of this WMP was 1940-2009. There was significant weather variability during this period, which resulted in variability in agricultural demands. For example, see Figure 2-1 which illustrates the irrigation water demand variability since 1989 based upon the annual LCRA Water Use Reports. Thus, as has been done in previous revisions to the WMP, weather-varied water demands have been used for model simulations. See Appendix A, Technical Paper A-2 for a more detailed description of how these weather-varied water demands for agriculture were determined.

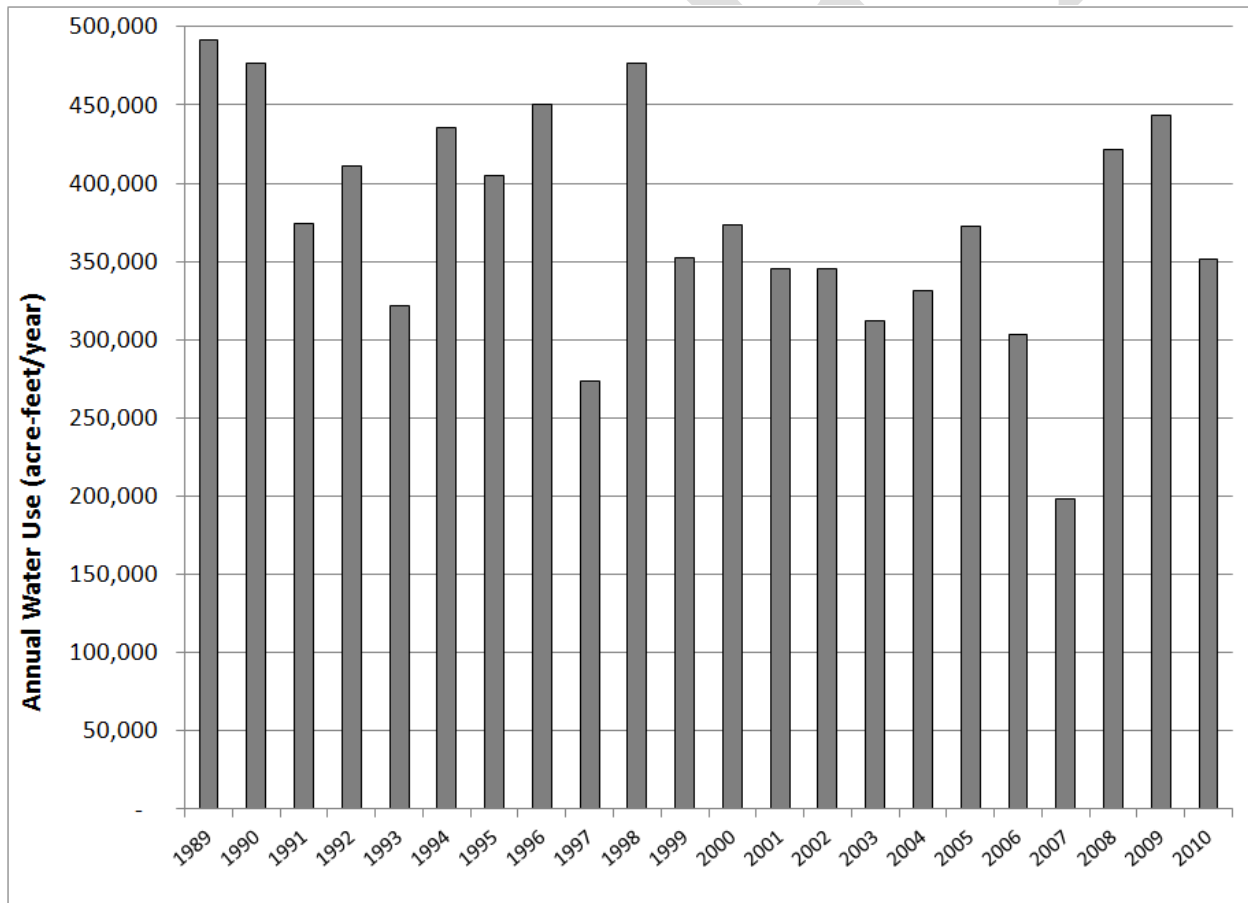
A unique aspect of agricultural water use in the lower Colorado River basin is that agricultural demands are not necessarily the same as the amount of water needed to be released from the lakes. Water from the lakes is ordered five to seven days before it is needed downstream because of travel time. Thus, if there is significant rainfall below the Highland Lakes between the time the water is released from the lakes and the time it arrives at the irrigation operations' diversion points, some or all of the water would no longer be needed by the irrigation operations. To more accurately simulate releases to meet the downstream diversions, factors were developed based on actual orders and diversions for the irrigation seasons of 2001 through 2010. The monthly factors representing the amount of water ordered divided by the amount of water diverted by irrigation operation are shown in Table 2-3.

In some instances, undiverted orders become a potential source of water for downstream users such as the South Texas Project Nuclear Operating Company, instream flows and freshwater flows to Matagorda Bay. As seen in Table 2-3, the Gulf Coast operation has historically been the most efficient at diverting its orders, which is likely due to the presence of the Lane City and Bay City dams. Similarly, Garwood also has a small pumping pool and is nearly as efficient. Neither Lakeside nor Pierce Ranch have pumping pools on the river, which likely influences their higher proportion of orders not being diverted.

**Table 2-2. Projected Diversions by Irrigation Operation**

Year	Irrigation Operation				
	Garwood (a-f/yr)	Lakeside (a-f/yr)	Gulf Coast (a-f/yr)	Pierce Ranch (a-f/yr)	Total (a-f/yr)
2010	92,400	139,700	178,700*	27,700	438,500
Interim	92,400	139,700	178,700*	27,700	438,500
2020	89,700	135,500	147,400*	27,000	399,600
2030	87,100	131,300	116,100	26,200	360,700
Notes: *Adjusted upward from WSRP and TWDB projections to the 2008 and 2009 average use					

**Figure 2-1 – Historic Water Use in Four Downstream Irrigation Operations**



**Table 2-3. Orders over Diversion Factors used in Water Availability Models**

Month	Average Factor by Irrigation Operation			
	Garwood	Lakeside	Pierce	Gulf Coast
March	1.20	3.63	1.38	1.17
April	2.06	3.42	1.91	1.53
May	1.28	1.23	1.32	1.06
June	1.26	1.38	1.38	1.11
July	1.75	1.93	2.60	1.39
Aug	1.24	1.46	1.32	1.10
Sept	1.43	1.88	1.71	1.33
October	1.62	1.78	2.39	1.18
Annual	1.35	1.46	1.75	1.23

## 2.4 ENVIRONMENTAL NEEDS FOR INSTREAM FLOWS AND BAY AND ESTUARY INFLOWS

The waters of the lower Colorado River basin help support a diverse and healthy aquatic habitat along the Colorado River downstream of Austin and in Matagorda Bay. Under the WMP, water is made available to help meet varying environmental flow levels based upon the combined storage in lakes Buchanan and Travis. The environmental flow needs are described in the following subsections.

### 2.4.1 Instream flows

The aquatic environment of the lower Colorado River downstream of Austin can be affected by the quality, quantity and timing of water flowing through the ecosystem. Streamflow is a key variable that influences riverine habitat, biology, geomorphology and water quality. A range of flow conditions is necessary to maintain healthy ecosystems.

A comprehensive instream flow study was completed in 2008 that investigated the flow relationships to aquatic habitat and the state-threatened blue sucker fish.<sup>7</sup> The study approach was consistent with the Texas Instream Flow Program methodology designed to support “a sound ecological environment,” which is described as “...a functioning ecosystem characterized by intact, natural processes, resilience, and a balanced, integrated, and adaptive community of organisms comparable to that of the natural habitat of the region.” The study collected extensive biological and physical data to develop hydraulic, habitat, water quality and sediment transport models. These models were used to support the development of the subsistence and base flow recommendations.<sup>8</sup>

- The subsistence flow recommendations represent minimum conditions at which water quality is maintained at acceptable levels and aquatic habitats are expected to be consistent with those found in natural settings during drought conditions. Dissolved

oxygen is expected to be maintained at 5.0 mg/L, or above, at all sites. This level of dissolved oxygen supports a healthy aquatic community. Special consideration for the state-threatened blue sucker is reflected in the February and March recommendations for instream flows at the Bastrop and Columbus gauges. Subsistence recommendations for these months and these sites were adjusted to help ensure that 90 percent of the spawning habitat is maintained during these key spawning times.

- The base flow recommendations provide habitat conditions and year-to-year variability sufficient to maintain a sound ecological environment. A comprehensive evaluation of the habitat model results, duration curves, exceedance tables, and water quality and sediment transport modeling led to the development of two base flow recommendations called Base-Dry and Base-Average. These recommendations are designed to provide the variability in habitat type, amount and distribution needed to support a sound ecological environment.

Subsistence and base flow recommendations for each month are presented in Table 2-4.

**Table 2-4. Subsistence and Base Flow Recommendations by Gauge (cubic feet per second)**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Austin												
Subsistence	50	50	50	50	50	50	50	50	50	50	50	50
Bastrop												
Subsistence	208	274	274	184	275	202	137	123	123	127	180	186
Base-Dry	313	317	274	287	579	418	347	194	236	245	283	311
Base-Average	433	497	497	635	824	733	610	381	423	433	424	450
Columbus												
Subsistence	340	375	375	299	425	534	342	190	279	190	202	301
Base-Dry	487	590	525	554	966	967	570	310	405	356	480	464
Base-Average	828	895	1,020	977	1,316	1,440	895	516	610	741	755	737
Wharton												
Subsistence	315	303	204	270	304	371	212	107	188	147	173	202
Base-Dry	492	597	531	561	985	984	577	314	410	360	486	470
Base-Average	838	906	1,036	1,011	1,397	1,512	906	522	617	749	764	746

## 2.4.2 Bay and estuary

The Colorado River along with other area rivers and streams provide freshwater inflows into the Matagorda Bay system. In the early 1990s, the Colorado River was re-routed to increase the freshwater inflows into West Matagorda Bay and now contributes approximately 40 percent of the total inflow on an average annual basis. The Matagorda Bay system is the second largest estuary on the Texas Gulf Coast. The abundant production of finfish and shellfish make this environmentally sensitive area an important ecological resource and a source of economically

significant commercial and sport fisheries. Many factors, including freshwater inflows, contribute to this high natural productivity. The seasonality of these flows is also important to the health and productivity of the bay.

The Matagorda Bay Health Evaluation (MBHE) used the latest data and science to assess the relationship between various factors and bay conditions.<sup>9</sup> Several measures of bay health were investigated, including salinity, habitat condition, species abundance, nutrient supply and benthic condition. The computer models and data analysis in the study were used to develop inflow criteria for the Colorado River. Salinity, habitat and benthic modeling were used to develop criteria for most levels, but additional measures of bay health were used wherever possible.

The recommended Colorado River inflow criteria from the MBHE study were designed to cover the full range of inflow conditions into Matagorda Bay, with a regime that incorporates five levels of inflow. The lowest level, “Threshold,” is a fixed monthly value to provide refuge conditions. The remaining levels, MBHE-1 through MBHE-4, represent different inflow targets that LCRA would seek to meet, depending on the combined storage of lakes Travis and Buchanan. The levels all include seasonal variability and incorporate influxes of fresh water into the Bay in the spring and fall that reflect the natural pattern of inflows into the bay. The MBHE freshwater inflow categories and descriptions are summarized in Table 2-5. The inflow values associated with these inflow criteria are presented in Table 2-6.

**Table 2-5. Summary of Matagorda Bay Health Evaluation Inflow Criteria**

Inflow Criteria	Descriptions
Threshold	Refuge conditions for all species and habitat
MBHE 1	Maintain tolerable oyster reef health, benthic character, and habitat conditions
MBHE 2	Provide inflow variability and sustain oyster reef health, benthic condition, low estuarine marsh, and shellfish and forage fish habitat
MBHE 3	Provide inflow variability and support quality oyster reef health, benthic condition, low estuarine marsh, and shellfish and forage fish habitat
MBHE 4	Provide inflow variability and support high levels of primary productivity, and high quality oyster reef health, benthic condition, low estuarine marsh, and shellfish and forage fish habitat

**Table 2-6. Matagorda Bay Health Inflow Criteria (acre-feet)**

Inflow Category	Spring (3 month total)	Fall (3 month total)	Intervening (6 month total)	Monthly
Threshold	-	-	-	15,000
MBHE 1	114,000	81,000	105,000	-
MBHE 2	168,700	119,900	155,400	-
MBHE 3	246,200	175,000	226,800	-
MBHE 4	433,200	307,800	399,000	-

For purposes of this WMP revision, “Operational Criteria” have been developed to help meet the

range of freshwater inflow needs associated with the MBHE levels 1 through 4. To help meet MBHE criteria, the MBHE three-month “spring” and “fall” and six-month “intervening” flow totals for a given inflow category are converted into equivalent two-month Operational Criteria as shown in Table 2-7. These running two-month values are applied in seasonal periods representing spring, fall and intervening. For example, the MBHE-1 spring three-month total of 114,000 acre-feet is converted into a two-month Operational Criteria of 76,000 acre-feet that would apply for the two-month periods ending in March, April, May and June. The MBHE fall three-month inflow value is used to define a two-month Operational Criteria that applies in the two-month periods ending in the months of July through October. Similarly, the MBHE intervening six-month inflow total is converted to a two-month Operational Criteria that applies in the two-month periods ending in November through February. The monthly Threshold bay inflow need applies in every month, regardless of the season or inflow level sought to be achieved.

**Table 2-7. Operational Criteria for Matagorda Bay Inflows**

Inflow Category	Two-Month Operational Criteria applicable in the individual months (acre-feet)		
	Spring March-June	Fall July-Oct	Intervening Nov-Feb
OP-1	76,000	54,000	35,000
OP-2	112,000	80,000	52,000
OP-3	164,000	117,000	76,000
OP-4	289,000	205,000	133,000

## 2.5. HYDROELECTRIC POWER GENERATION

Hydroelectric power plants are located at each of the dams owned and operated by LCRA and total approximately 291 megawatts of capacity. Until the 1960s, the hydroelectric plants represented LCRA’s total capability for generating electric energy. The Final Judgment and Decree of LCRA’s water rights recognize the competing needs for the stored water in the reservoirs. As a result, hydropower has been subordinated, except in emergencies, to be a by-product of the release of water for other purposes or when hydropower generation will not impair LCRA’s ability to satisfy all stored water demands. To the maximum extent possible, releases of water are made in a manner to take maximum advantage of the energy produced by those releases. LCRA retains the right to make releases solely for hydropower production in times of emergencies as part of the WMP operating policies. Such emergencies may include, among other things: a) LCRA receives direction from the Electric Reliability Council of Texas (ERCOT), Independent System Operator, or other regulatory authority to generate, and no exception to the order exists under ERCOT protocols; b) there is the existence of a threat to LCRA’s generation and/or transmission systems that may result in the potential need to cutoff firm electric customers; c) when LCRA is not curtailing availability of interruptible supply to the four downstream irrigation operations and LCRA cannot internally meet its own power requirements with available generation or by starting up another LCRA unit; and d) LCRA providing

responsive reserve service and nonspinning reserve service, which, if called upon by ERCOT or other regulatory authority, may result in releases of water.

## 2.6. LAKE/RIVER RECREATION AND ECONOMIC INTERESTS

In many areas, recreational uses of the river and lakes are steadily increasing. The entire lower Colorado River basin, from Lake Buchanan to Lady Bird Lake, and the river downstream to Matagorda Bay and the Gulf of Mexico, receives a great deal of recreational use from fishermen, boaters, park visitors and swimmers from all over Texas. Furthermore, significant economies have developed around these areas, particularly around the Highland Lakes.

Because the reservoirs were built for flood management and water supply and not constructed to maximize recreational use, the demands for higher lake levels can be difficult to accommodate. Similarly, providing a river recreation flow below Austin would also impact the available water supply.

Low lake levels can have an adverse impact on the regional economy surrounding lakes Buchanan and Travis. In prior WMPs, in recognition of the economy around the Highland Lakes, LCRA limited the sales of interruptible stored water other than for the four irrigation operations. Under this WMP, the supply of interruptible water outside of the four downstream irrigation operations will be further limited as discussed in Chapter 4.

## 2.7 WATER QUALITY

Protecting water quality in the Highland Lakes and the Colorado River is an important part of LCRA's mission. The primary threats to water quality are discharges from industry and wastewater treatment plants (point source pollution), stormwater runoff that carries pollutants and contaminants (nonpoint source pollution), soil erosion, reservoir sedimentation and dissolved oxygen problems.

While the WMP is designed to manage lakes Buchanan and Travis to provide firm and interruptible water supply and help meet environmental needs, the instream flow recommendations also provide for water quality protection as discussed in Section 2.4.1 of this Chapter. Currently, there are a several LCRA programs in place to protect and enhance river and lake water quality. These programs include:

- *On-site Sewage Facilities Program:* LCRA is authorized by the state of Texas to inspect and license septic tanks near the Highland Lakes. <http://www.lcra.org/water/quality/oss/index.html>
- *Watershed Ordinance:* LCRA manages stormwater runoff from existing and new development around the Highland Lakes by applying and enforcing the Highland Lakes Watershed Ordinance. <http://www.lcra.org/water/quality/watershed/index.html>



- *Colorado River Watch Network*: Program that supports citizens who volunteer to monitor water quality throughout the lower Colorado River basin.  
<http://www.lcra.org/water/quality/crwn/index.html>
- *Texas Clean Rivers Program*: State funded partnership of river authorities and other agencies that monitor and assess water quality issues.  
<http://www.lcra.org/water/quality/crp/index.html>
- *Application Review and Response Program*: LCRA reviews and can respond to permits issued by other agencies that may affect water quality in the lower river basin.  
<http://www.lcra.org/water/quality/protectingwaterqualitypage.html>
- *Water Quality Models*: To help manage the basin more effectively, LCRA has developed water quality models for the Highland Lakes.  
<http://www.lcra.org/water/quality/models.html>

## 2.8 FLOOD CONTROL

In addition to managing the Highland Lakes for water supply, LCRA also operates the lakes for flood control purposes. Lake Travis has dedicated flood control storage above elevation 681 feet mean sea level (msl). When water is in the flood storage pool, LCRA operates Mansfield Dam in accordance with U.S. Army Corps of Engineers criteria as discussed further in Chapter 5.

- 
1. LCRA, [Water Supply Resource Plan](#), and supporting spreadsheets, October 2010.
  2. Parsons, [Future Irrigation Water Diversions, 2010-2090](#), Final Report Prepared for LCRA and SAWS, Sept. 1, 2006.
  3. LCRA, An Update to Irrigation Water Use Predictions For the Four Agricultural Water Operations in the Lower Colorado River Service Area, June 14, 2010.
  4. LCRA, [Water Supply Strategies For Agriculture](#), June 2011.
  5. Texas Water Development Board and Lower Colorado Regional Planning Group, 2001 Adopted Regional Water Plan, December, 2000.
  6. Texas Water Development Board and Lower Colorado Regional Planning Group, 2006 Adopted Regional Water Plan, January 2006.
  7. Colorado River Flow Relationships to Aquatic Habitat and State Threatened Species: Blue Sucker, BIO-WEST, Inc., 2008.
  8. Texas Instream Flow Program Studies, Technical Overview Report 369.
  9. Matagorda Bay Health Evaluation Study, Final Report Prepared for LCRA and SAWS, 2008.

## **CHAPTER 3**

### **WATER AVAILABILITY MODELING**

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#### **3.1 BACKGROUND**

During the last Water Management Plan (WMP) revision process, LCRA's RESPONSE Model for the lower Colorado River basin was used to evaluate different alternatives for managing lakes Buchanan and Travis. The RESPONSE model simulated the operations of lakes Buchanan and Travis and major water rights downstream of the Highland Lakes for the period 1941-1965. The model used inflows to the Highland Lakes derived from some of the first water availability models developed by the predecessor agencies of the Texas Commission on Environmental Quality (TCEQ) in the 1970s and 1980s.

Texas Senate Bill 1 (75<sup>th</sup> Legislature in 1997) brought about the creation of new water availability models (WAMs) for all river basins in Texas. As part of this process, the WAM for the Colorado River Basin (Colorado WAM) was completed in 2001 and included inflows for the historical hydrologic period of record from 1940-1998, over twice as many years as the RESPONSE model.

Since the Colorado WAM was completed, it has been consistently updated and improved by TCEQ and others and is used on a day-to-day basis by the TCEQ to evaluate water rights permit applications. It is also used by the Texas Water Development Board (TWDB) for regional water planning purposes. For this WMP revision process, LCRA modified the most current version of TCEQ's WAM to include the recent intense droughts experienced in the 1999-2009 period. Thus, the hydrologic period of record in the WAM used for the WMP (WMP WAM) is 1940-2009.

#### **3.2 WAM VERSIONS USED IN THE WATER MANAGEMENT PLAN**

As part of the WMP update process, LCRA developed three variations of the WMP WAM to compute the combined firm yield of lakes Buchanan and Travis and to assess how changes in firm water demands and curtailment procedures for interruptible stored water would impact LCRA's firm and interruptible water supply customers, environmental flows (instream and freshwater inflows to Matagorda Bay) and lake levels. The three variations of the Colorado WAM are:

- Baseline Models (2010 WMP) with 2010, 2020 and 2030 demands;
- Interim WMP WAM and the 2020 WMP WAM; and
- Firm Yield Model.

The model assumptions used in each of the above models are described in detail in the following technical papers included under Appendix A:

- Technical Paper A-3, Assumptions Underlying LCRA 2010 Water Management Plan Baseline Water Availability Models;
- Technical Paper A-4, Assumptions Underlying Water Availability Models Used to Support Development of the LCRA Water Management Plan Revisions; and
- Technical Paper A-5, Development of Combined Firm Yield of Lakes Buchanan and Travis.

Generally, the Baseline Models were created to summarize the current 2010 WMP. In addition, these models served as a starting point against which LCRA and the Water Management Plan Revision Advisory Committee could compare and assess the impacts of various curtailment procedures.

The Interim and 2020 WMP WAMs incorporate the curtailment procedures developed for this WMP revision. These models were developed over many months by LCRA, with input from the committee.

The third variation of the WMP WAM, the Firm Yield Model, was developed to compute the combined firm yield of lakes Buchanan and Travis. This model's parameters and assumptions relate to the legal representation of all water rights in the basin and assume all other rights in the Colorado Basin exercise the full legal amounts authorized by their associated water rights, regardless of what these water rights' demands actually are or are anticipated to be. This model also incorporates the settlement agreement between LCRA and the City of Austin regarding treatment of return flows discharged by the City of Austin as it impacts the firm yield of lakes Buchanan and Travis.

The Baseline, Interim and 2020 WMP WAMs include parameters and assumptions that relate to actual and anticipated conditions and thus are referred to as "operational models." Because these models are constructed to assess significantly different aspects of water availability than the Firm Yield Model, there are numerous differences in assumptions between models, the most notable of which are summarized in Table 3-1.

**Table 3-1**  
**Differences Between Operational and Firm Yield Models**

Model Parameter	Baseline Models	Interim & 2020 Models	Firm Yield Model
Period of record	1940-2009	1940-2009	1940-2009
Reservoir sedimentation conditions	Year Specific	Year Specific	Year Specific
Priority "cutoff" assumption <sup>1</sup>	Buchanan & Travis	Buchanan & Travis	Ivie and Brownwood
Municipal and industrial demands	Year Specific	Year Specific	Authorized Amount
Irrigation demands	Year Specific	Year Specific	Authorized Amount
Irrigation demand curtailment	2010 WMP	As Proposed	No
Climate variable irrigation demands	Yes	Yes	No
Irrigation return flows represented	Yes	Yes	No
Stored water provided for irrigation	Yes	Yes	No
Run-of-river diversions for lower basin senior rights limited to estimates of reliable water	Yes	Yes	No
Pass-through and stored water releases from Highland Lakes to lower basin users increased to represent daily inefficiencies in actual operations	Yes	Yes	No
City of Austin return flows included	Yes	Yes	Yes
Environmental flows represented	2010 WMP	As Proposed	No

Note: 1. All water rights of the reservoirs noted are represented as being able to divert and store water with priority over all water rights downstream of these upstream reservoirs regardless of the actual priority date stated in their water rights. For Baseline, Interim and 2020 models, this assumption is appropriate because water rights at and below the Highland Lakes do not have a current process in place to monitor upstream junior water rights to ensure inflows are passed downstream to senior water rights holders. For the Firm Yield model, this assumption is appropriate because several of the large water rights at the Highland Lakes and downstream have "no call" agreements in place with numerous entities upstream of these reservoirs.

### 3.3 INTERIM AND 2020 WMP MODELS

The Interim and 2020 WMP WAMs were created to represent operating provisions of this WMP revision. The Interim WMP WAM uses interim demands (about half way between the projected 2010 and 2020 water demands) and the 2020 WMP WAM uses projected year 2020 water demands. These WMP WAMs include the proposed operating procedures and irrigation curtailment details developed with input from the Water Management Plan Revision Advisory Committee.

The purpose of these operations-based models was to assess how changes in firm water demands and curtailment procedures for interruptible stored water would impact various parameters associated with LCRA's firm and interruptible water supply customers, environmental flows (instream and freshwater inflows to Matagorda Bay) and lake levels through a repeat of the historical hydrology for the period 1940-2009. These operational models are designed to simulate the impact of LCRA's customers' demands and environmental flow criteria on the Highland Lakes and the Colorado River downstream based on a repeat of the historical hydrology. Numerous parameters in these models were set to represent actual operational characteristics and to also recognize several practical limitations associated with the Highland Lakes and lower basin water users' ability to use Colorado River water. Modeling assumptions underlying the Interim and 2020 WMP WAMs are described in more detail in Appendix A, Technical Paper A-4.

### 3.4 FIRM YIELD COMPUTATION

The 1988 Final Judgment and Decree (1988 Decree) adjudicating LCRA's Highland Lakes water rights requires that LCRA calculate the combined firm yield of lakes Travis and Buchanan. For purposes of the WMP, the combined firm yield of lakes Buchanan and Travis is defined as:

That amount of water, that the reservoir [system] could have produced annually if it had been in place during the worst drought of record. In performing this simulation, naturalized streamflows will be modified as appropriate to account for the full exercise of upstream senior water rights is assumed as well as the passage of sufficient water to satisfy all downstream senior water rights valued at their full authorized amounts and conditions as well as the passage of flows needed to meet all applicable permit conditions relating to instream and freshwater inflow requirements.<sup>1</sup>

Further, consistent with the 1988 Decree, the combined firm yield represents the maximum amount of water that LCRA can commit from lakes Buchanan and Travis for firm water supply.

The concept of firm yield of a reservoir or system of reservoirs is fundamental to water supply planning. It defines a reliable level of supply that can be reasonably expected to be available in the future should a drought occur that is as severe as the Drought of Record. It is also possible for a drought more severe than the Drought of Record to occur in the future, in which case the full firm yield amount would not be available.

A water availability model (WAM) was used to calculate the combined firm yield of lakes Buchanan and Travis. The computer model accounts for all surface water rights in the Colorado River basin and uses historical streamflow data, hydrology and climatic conditions to simulate the supply of surface water available on a monthly basis. This model also incorporates the settlement agreement between the LCRA and the City of Austin<sup>2</sup> regarding treatment of return flows discharged by the City of Austin as it impacts the combined firm yield of lakes Buchanan and Travis. The combined firm yield of lakes Buchanan and Travis (separate from O.H. Ivie) as calculated in this WMP revision is 434,549 acre-feet per year as compared to the value of 445,266 acre-feet per year calculated in the original WMP,<sup>3</sup> approximately a two percent reduction. A more technical explanation of the firm yield calculation and the assumptions that were used in the calculation can be found in Appendix A -Technical Paper A-5.

### 3.5 CALIBRATION SUMMARY

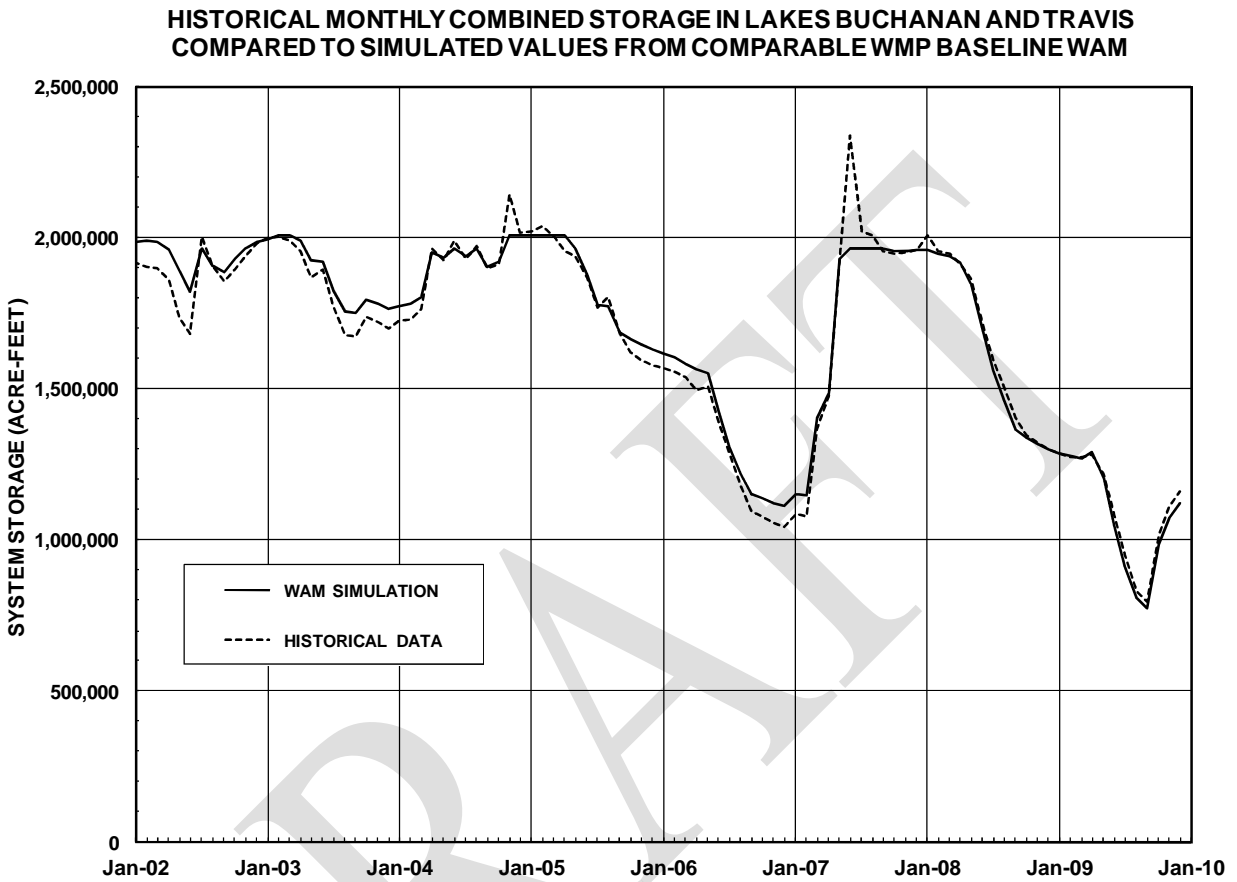
At the beginning of the WMP update process, a modified Baseline WAM was created to evaluate the effectiveness of the WAM models at simulating the interactions between upstream and downstream river flows, releases and diversions, and reservoir storage. The modified Baseline WAM used the curtailment procedures from the 1999 WMP (which was in effect through 2009). The results of the modified Baseline WAM were compared with actual observed hydrologic data for the period from 2002-2009, which includes a variety of low and high flow conditions. Specific comparisons were made of:

- Lake levels for lakes Buchanan and Travis;
- Combined LCRA system storage;
- River flows at gauges downstream of the Highland Lakes; and
- Total amount of Colorado River flow reaching Matagorda Bay.

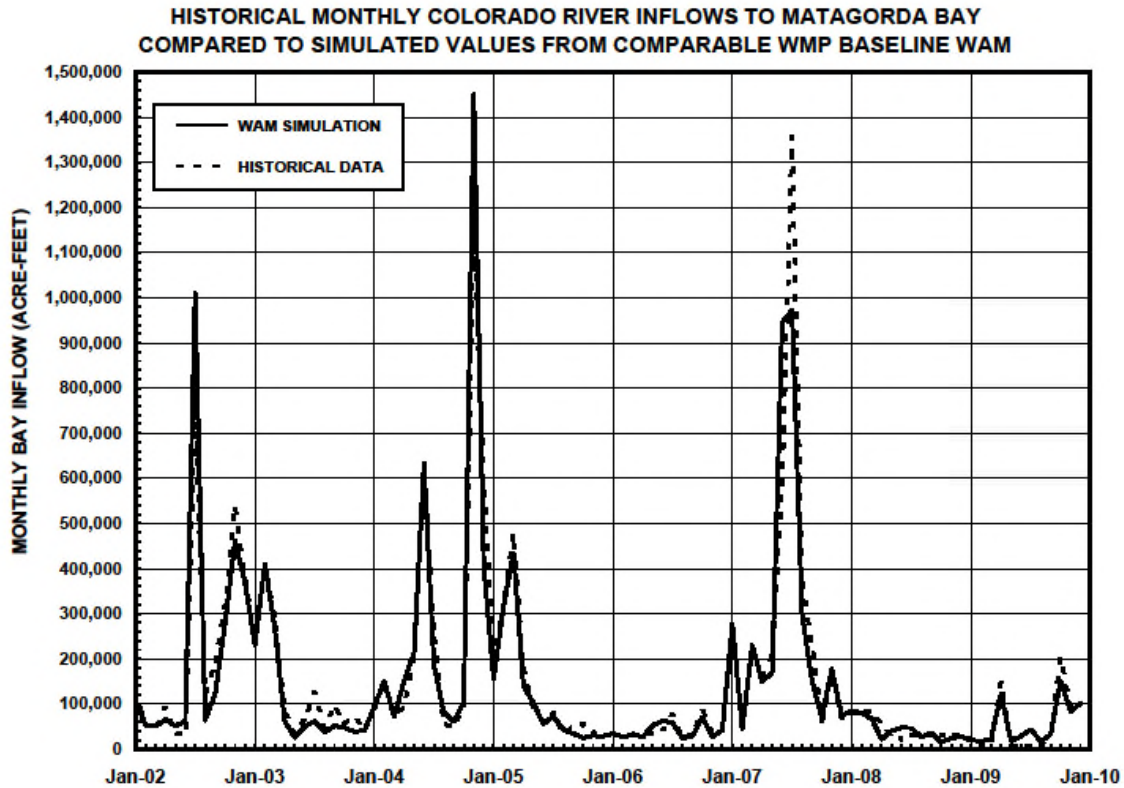
These comparisons demonstrated the Baseline WAM's ability to accurately simulate lakes Buchanan and Travis, releases from these reservoirs and the river flows in the lower Colorado River. Figures 3-1 and 3-2 illustrate the comparisons for combined storage of lakes Buchanan and Travis and for the total inflows to Matagorda Bay. As can be seen in the figures, the Baseline WAM simulated values generally track closely with the observed data with a few exceptions, most of which are expected due to the following inherent differences between the Baseline WAM model logic and historical operations:

- The WAM model simulation was run for the full period beginning in 1940, therefore at the beginning of the comparison in 2002, the quantity in storage in the WAM model did not exactly match the historical data;
- The WAM does not store water in reservoirs above the conservation pool (the elevation associated with maximum water supply storage); and,
- Firm demands in the Baseline WAM are assumed to be the same each year of the simulation and set to 2010 levels, while the historical data reflects the year-to-year variations in actual water use.

**Figure 3-1**  
**Comparison of Combined Storage in Lakes Buchanan and Travis**



**Figure 3-2**  
**Comparison of Total Flow to Matagorda Bay**



1. 30 Tex. Admin. Code § 297.20(1).
2. June 18, 2007, Settlement Agreement by and between the City of Austin and the Lower Colorado River Authority Regarding Joint Water Resource Management and the Resolution of Certain Regulatory Matters Pending at the Texas Commission on Environmental Quality, Section VIII.C
3. Sept. 7, 1989, Texas Water Commission Order Approving Lower Colorado River Authority's Water Management Plan Amending Certificates of Adjudication Nos. 14-5478 and 14-5482, Finding of Fact 47.



**CHAPTER 4**  
**ALLOCATION OF STORED WATER SUPPLIES, FIRM CUSTOMER DROUGHT**  
**CONTINGENCY PLAN, AND AGRICULTURAL CUSTOMER DROUGHT**  
**CONTINGENCY PLAN**

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#### 4.1. INTRODUCTION

This Water Management Plan (WMP) contains a number of distinct trigger levels and conditions that are associated with determining the amount of interruptible stored water available from lakes Buchanan and Travis to try to help meet:

- Agricultural (irrigation) demands in the four downstream irrigation operations;
- A range of freshwater inflows for Matagorda Bay;
- A range of instream flows downstream of the Highland Lakes; and
- Demands for a small category of interruptible users, other than the downstream irrigation operations, when the combined storage in lakes Buchanan and Travis is above 1.9 million acre-feet (MAF).

Demands for interruptible stored water to supplement available run-of-river water supplies for agricultural (irrigation) purposes (mainly rice production) can be particularly high during drier conditions. These types of conditions, combined with a significant projected growth in firm demands through 2020, increase the likelihood of significant shortages of interruptible stored water. Thus, significant changes to the interruptible stored water curtailment policies from prior Water Management Plans are necessary to address this possibility.

When developing the triggers and curtailment mechanisms contained in this WMP revision, LCRA staff reviewed with the Water Management Plan Revision Advisory Committee (WMPRAC) numerous Water Availability Model (WAM) runs. These runs evaluated many different options for allocating available interruptible stored water from lakes Buchanan and Travis between irrigation and environmental needs.

When determining available interruptible stored water supplies, it is essential that firm water demands be protected during a repetition of the Drought of Record (DOR)<sup>1</sup>. This drought is the worst recorded to date on the lower Colorado River and is from 1947 through 1957. The curtailment procedures in this WMP revision have been designed to ensure supply is available to meet projected firm demands through the year 2020, through a DOR condition and through the short-term intense droughts that this region has experienced in recent decades, as required by the January 2010 TCEQ Order approving the 2010 WMP.<sup>2</sup>

The TCEQ Order also required an evaluation of the minimum combined storage in lakes Buchanan and Travis necessary or appropriate to protect firm customers through a DOR condition, or under conditions worse than a Drought of Record. Since the evaluation of expected hydrologic and water demand conditions can only be simulated based on projected information, which is subject to some uncertainty, in all of its prior WMPs LCRA has determined it prudent to

designate some minimum storage level. This served as a safety factor to address model uncertainties and provide for hydrologic conditions other than those simulated.

The minimum storage in the model simulations for this WMP revision was maintained in a range of roughly 375,000 to 400,000 acre-feet. This safety factor is roughly equivalent to the volume needed in storage to meet approximately one year of firm demands under severe drought conditions. In all previous WMPs, a safety factor of about 200,000 acre-feet was used. The increase to 375,000-400,000 acre-feet roughly corresponds to the increase in total firm demands since the first WMP. Thus, the level of protection for firm demands under this WMP revision is roughly equivalent to that of the first WMP.

As discussed in Chapter 2, by 2020, demands of LCRA's firm water customers are projected to increase by approximately 48 percent from the projected year 2010 demand values used in the 2010 WMP. Meeting those increased demands from lakes Buchanan and Travis can only be achieved by decreasing the amount of interruptible stored water provided under the 2010 WMP.

This WMP revision includes a number of significant changes to the methods used to allocate interruptible stored water from lakes Buchanan and Travis for agricultural use in the four downstream irrigation operations and to other users. It also includes changes to the environmental criteria used to provide instream flow below Longhorn Dam and freshwater inflow into Matagorda Bay. These changes allow LCRA to be more responsive to changes in water supply conditions. Specifically, these changes include:

- LCRA will determine availability of interruptible stored water for the downstream irrigation operations separately for first and second crop;
- LCRA will determine applicable environmental flow criteria at two dates during the year for different periods of the year;
- LCRA will increase the amount of interruptible stored water available for the downstream irrigation operations if combined storage increases between Jan. 1 and March 1 for first crop or, for second crop, between June 1 and Aug. 1;
- An annual cap on the total amount of interruptible stored water available for contracting in any given calendar year, and LCRA will adjust the amount of interruptible stored water available for second crop to stay within the annual cap;
- In the initial years in which this plan is in effect, LCRA will use less-restrictive curtailment procedures for determining available interruptible stored water. LCRA will shift to more restrictive curtailment procedures designed for year 2020 firm demands when specific triggering events occur (based on increases in actual demands, water supply conditions, or a time certain);
- LCRA will stop releasing interruptible stored water for the downstream irrigation operations other than Garwood when combined storage drops below 600,000 acre-feet, whether or not the LCRA Board has declared of Drought Worse than Drought of Record; and
- The LCRA Board will have increased discretion to determine the amount of interruptible stored water available to the downstream irrigation operations under certain severe dry weather conditions, and to determine the amount of assumed run-of-river water available to the Gulf Coast irrigation operation under certain wet forecast conditions.

This Chapter also incorporates LCRA's Drought Contingency Plans (DCPs) for its firm water customers and its downstream irrigation operations. Updates to this chapter may be made as discussed in Section 4.10.

#### 4.2. PROCESS FOR DETERMINING APPLICABLE CURTAILMENT PROCEDURES

For this WMP revision, LCRA used a planning horizon through year 2020 designed to protect firm demands through a repeat of the Drought of Record and other short-term intense droughts as have been experienced in recent decades. Firm demands are expected to increase through year 2020. However, to make the WMP more adaptive to actual firm demands and demand growth, LCRA has developed two separate sets of curtailment procedures, including curtailment curves for the four irrigation operations and environmental flow criteria. The first "interim" set applies immediately, and the second "2020" set will apply when certain specific conditions are met, including increasing firm demands or other conditions. (The curtailment procedures for the downstream irrigation operations are presented in section 4.3 and the environmental flow criteria are presented in section 4.5.) By creating two sets of curtailment procedures and a mechanism for shifting between the two, this WMP allows LCRA to be more adaptive. This provides more interruptible stored water in the initial years of operation under this WMP and implements more restrictive curtailment procedures over time.

The interim demand phase curtailment procedures will be in effect immediately upon the effective date of this WMP. The LCRA Board will determine whether to shift to the 2020 curtailment procedures after opportunity for public comment and in accordance with the criteria set forth below. Specifically, the shift to 2020 curtailment procedures would be effective for the next calendar year upon a finding by the LCRA Board that any one or more of the following criteria with respect to actual or projected demands for firm water from lakes Buchanan and Travis is met:

1. Actual demand plus projected incremental water use from new or existing contracts expected to come on-line in the next year is greater than or equal to 352,303 acre-feet per year (the firm water demand assumed for the interim curtailment procedures); or
2. Actual demand in any year is greater than 352,303 acre-feet; or
3. Actual demand exceeds 95 percent of 352,303 acre-feet per year (334,688 acre-feet per year) for two consecutive years;
4. Actual demands exceeds 334,688 acre-feet (95 percent of interim firm water demand) and a cancellation of Drought Worse than Drought of Record has occurred in the year in which the finding is made; or
5. The next calendar year is 2020.

If a shift has occurred under provision (1) described above and the projected demand increase does not materialize (i.e. the total demand in a given year is less than 352,303 acre-feet), and none of the other criteria for triggering a shift are met (including provision 1), the curtailment procedures will revert back to the interim procedures for the next year.

To determine whether a shift in curtailment procedures is warranted based on firm demand on lakes Buchanan and Travis, LCRA will calculate projected demands for the upcoming year by adding the following:

1. *Actual demands of firm water customers* – based on firm water customers’ previous year’s use as reported in the Water Use Reports prepared for TCEQ each year;
2. *Projections of water use from new contracts, contract amendments or existing contracts expected to come on-line in the next year* – short-term, forward-looking projection based on:
  - Increased demand projections of industrial customers with contracts or commitments greater than 5,000 acre-feet per year (AFY);
  - Increased demand projections for municipal customers with contracts or commitments greater than 2,500 AFY;
  - Miscellaneous growth in demand of 1,500 AFY to cover growth in demands for smaller users;
  - Factoring in the projected demands for any additional firm contracts issued by LCRA in the current or next year; and
3. *Additional projected demand components*
  - Factoring actual conveyance losses and emergency releases into the projection;
  - Adding back to the actual demands any reductions in demands in the previous year due to implementation of a customer’s Drought Contingency Plan (DCP), based on actual documented savings;
  - Adding an amount to account for actual use under LCRA’s firm water commitment to the South Texas Project Nuclear Operating Company (STPNOC) as follows:
    - If the five-year rolling average is greater than 20,000 acre-feet, then the difference between the five-year rolling average and 20,000 acre-feet shall be added to the projected demands;
    - If the five-year rolling average is less than 20,000 acre-feet, then no adjustment shall be made based on STPNOC’s water use;
  - LCRA will monitor Corpus Christi’s plans to divert water under its Garwood water rights and will consider and factor into these calculations, if necessary, any impact Corpus Christi’s projected diversions will have on the LCRA system on a year-to-year basis.

On or before Jan. 1 of each year, LCRA will conduct the following review process to evaluate and decide whether to shift from the interim demand curtailment procedures to the 2020 demand procedures for the following years:

- Gather actual firm water demands based on Water Use Report data submitted to TCEQ in March;
- From March through August, LCRA will gather input from larger municipal and industrial firm water customers on the upcoming year’s projected demand;

- Prior to LCRA's October Board meeting, LCRA will compile the upcoming year's projection of firm demands, post the draft projections on LCRA's website for review and comment, and notify firm and interruptible customers. The document will:
  - Identify the source(s) of all data used to compute the projected demands;
  - Define actual versus projected demands; and
  - Describe whether a shift in the curtailment curve is projected to occur.
- If any of the criteria above for a shift in curtailment procedures are met, LCRA will set the matter for consideration and possible action by the LCRA Board of Directors no later than at the December Board meeting; and
- LCRA will provide written notice to TCEQ if the LCRA Board acts to shift from the interim demand curtailment procedures to the 2020 demand curtailment procedures.

When the Water Management Plan is revised in the future, the planning process will incorporate demand projections developed at that time and not rely on projected demands in this plan revision.

#### 4.3. CURTAILMENT PROCEDURES FOR THE FOUR DOWNSTREAM IRRIGATION OPERATIONS

##### 4.3.1 Introduction

Section 4.3 presents the curtailment procedures that apply to releases of interruptible stored water for agricultural uses in the four downstream irrigation operations and serves as LCRA's Drought Contingency Plan for such uses.

##### 4.3.2 Determination of total amount of interruptible stored water available for the four downstream irrigation operations

The procedures for determining the total amount of interruptible stored water available for the four downstream irrigation operations include various elements and limitations as described in the following subsections. As with recent WMPs, evaluation of demands and the curtailment of interruptible stored water for Garwood and Pierce Ranch will be accomplished pursuant to the terms of specific agreements related to the supply of interruptible water to those operations.

##### 4.3.2.1. Separate determination of interruptible stored water for first and second crop

In previous versions of the WMP, LCRA used an annual allocation process based on the Jan. 1 combined storage level of lakes Buchanan and Travis to determine the amount of interruptible stored water available for diversion at the four downstream irrigation operations for both first and second crops of the irrigation season. This WMP has a separate allocation process for first and second crops. First crop availability of interruptible stored water will be based on Jan. 1 combined storage, with the possibility of increasing the supply if combined storage on March 1 is higher than on Jan. 1. Second crop availability of interruptible stored water will be based on

June 1 combined storage, with the possibility of increasing the supply if combined storage on Aug. 1 is higher than on June 1.

#### 4.3.2.2. Annual limit for the supply of interruptible stored water

Under this WMP, the maximum available interruptible stored water supply that will be made available for diversions in any given year to the four downstream irrigation operations will be limited even when storage levels in lakes Buchanan and Travis are relatively high or near full. On an annual basis, no more than 273,500 acre-feet per year will be available for diversions for first and second crop during the interim demand phase, and no more than 249,000 acre-feet per year would be available for diversion during the 2020 demand phase.

The annual supply limit shall be used to adjust the amount of water that may be made available to an individual irrigation operation in second crop if the following conditions exist:

- The use of interruptible stored water by an individual irrigation operation exceeded (or is projected to exceed) its allocation for first crop determined under Section 4.3.3; and
- The total use (or projected use) by all four irrigation operations in first crop, plus the total amount of interruptible stored water that would be made available for second crop under Section 4.3.2.3, would exceed the annual limit described above.

Under these conditions, the adjustment shall be limited to the amount necessary to stay within the annual limit.

The annual limit will be used to determine the water available during the contracting process. However, notwithstanding any adjustments made to water available for contracting during second crop, actual use could exceed the annual limit if necessary to complete a crop.

#### 4.3.2.3. Curtailment curves for the supply of interruptible stored water

Interruptible stored water will be made available for diversion based upon the applicable curtailment procedures (interim demand phase or 2020 demand phase) in effect for the calendar year. For first crop, the greater of the Jan. 1 or March 1 combined storage values will be used in conjunction with the applicable curtailment curves. For second crop, the greater of the June 1 or Aug. 1 combined storage values will be used in conjunction with the applicable curtailment curves.

The Interim Demand Phase and 2020 Demand Phase curtailment curves for first and second crops are shown in Figures 4-1 and 4-2, respectively. These curtailment curves include increases in the combined storage level below which interruptible stored water to Lakeside, Pierce Ranch and Gulf Coast would be cut off prior to beginning a crop season. In previous WMPs, the cutoff of interruptible stored water supply for agricultural use for the coming year would occur when the combined storage in lakes Buchanan and Travis on Jan. 1 was less than or equal to 325,000 acre-feet. The total amount of interruptible stored water to be made available for diversion at the

irrigation operations river pump stations for all four irrigation operations will be determined as follows:

**During the Interim Demand Phase:**

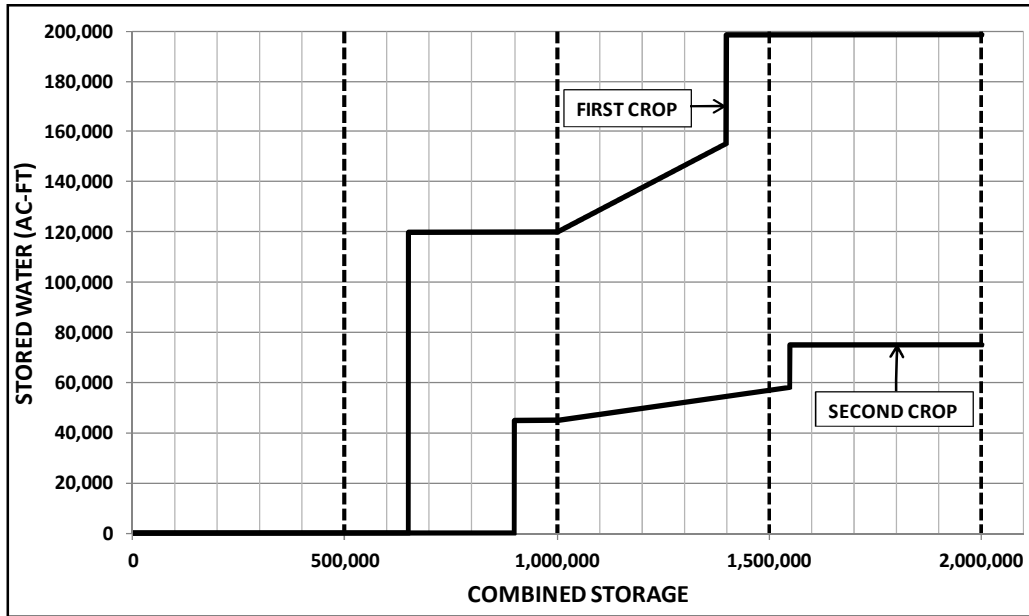
- First Crop:
  - For combined storage of 1.4 million acre-feet (MAF) or more, 198,500 acre-feet;
  - For combined storage between 1.399 MAF and 1 MAF, a sliding scale from 155,000 acre-feet at 1.399 MAF of storage to 120,000 acre-feet at 1 MAF of storage;
  - For combined storage from 999,999 acre-feet to 650,000 acre-feet, 120,000 acre-feet; and
  - Below 650,000 acre-feet, no water except for Garwood irrigation operation, consistent with prior agreements.
- Second Crop:
  - For combined storage of 1.55 MAF or more, 75,000 acre-feet;
  - For combined storage between 1.549 MAF and 1 MAF, a sliding scale from 58,000 at 1.549 MAF of storage to 45,000 acre-feet at 1 MAF of storage;
  - For combined storage from 999,999 acre-feet to 900,000 acre-feet, 45,000 acre-feet; and
  - Below 900,000 acre-feet, no water except for Garwood irrigation operation, consistent with prior agreements.

**During the 2020 Demand Phase:**

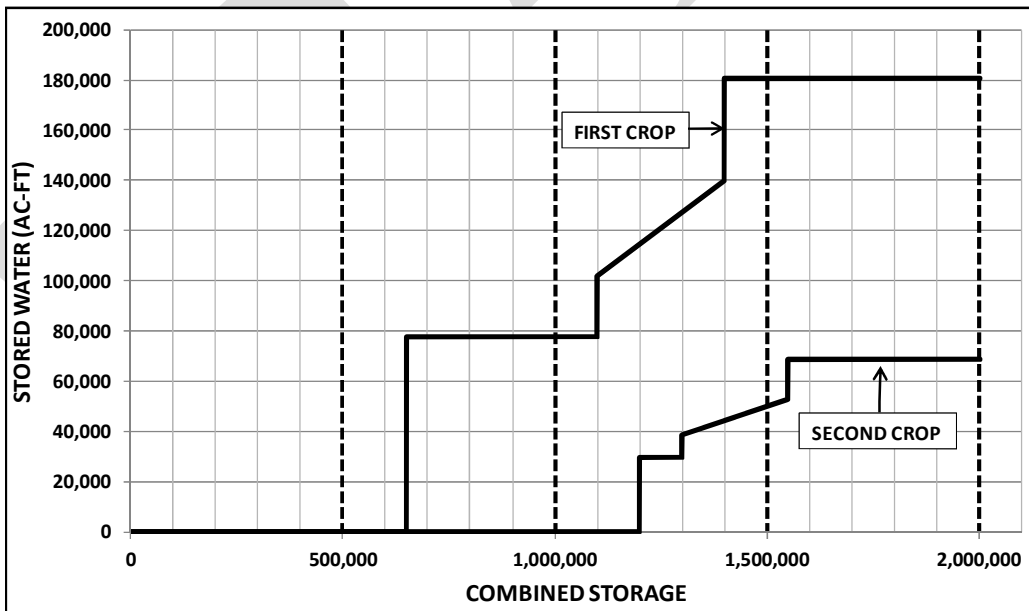
- First Crop:
  - For combined storage of 1.4 MAF or more, 180,500 acre-feet;
  - For combined storage between 1.399 MAF and 1.1 MAF, a sliding scale from 140,000 acre-feet at 1.399 MAF of storage to 102,000 acre-feet at 1.1 MAF of storage;
  - For combined storage between 1.099 MAF and 650,000 acre-feet, 77,500 acre-feet; and
  - Below 650,000 acre-feet, no water except for Garwood irrigation operation, consistent with prior agreements.
- Second Crop:
  - For combined storage of 1.55 MAF or more, 68,500 acre-feet;
  - For combined storage between 1.549 MAF and 1.0 MAF, a sliding scale from 53,000 at 1.549 MAF of storage to 38,500 acre-feet at 1.0 MAF of storage;
  - For combined storage between 999,999 acre-feet and 900,000 acre-feet, 29,500 acre-feet; and
  - Below 900,000 acre-feet, no water except for Garwood irrigation operation, consistent with prior agreements.



**Figure 4-1. Interruptible Stored Water Curtailment Curve  
for the Interim Demand Phase**



**Figure 4-2. Interruptible Stored Water Curtailment Curve  
for Year 2020 Demand Phase**



#### 4.3.2.4. Anytime cutoff of interruptible stored water supplies

Under this WMP, LCRA will cease supplying interruptible stored water from lakes Buchanan and Travis for agricultural use to Lakeside, Pierce Ranch and Gulf Coast when combined storage falls to 600,000 acre-feet. Previous plans set this cutoff level at 200,000 acre-feet. This cutoff could occur at any time in a crop season.

Furthermore, in the event that the LCRA Board declares a Drought Worse than Drought of Record, the supply of interruptible stored water shall be ceased immediately and no interruptible stored water shall be made available to all four downstream irrigation operations until the declaration is cancelled.

#### 4.3.2.5. Resumption of supply of interruptible stored water in a first crop season

If the interruptible stored water supplies for first crop have been cut off and LCRA is not under a declaration of Drought Worse than Drought of Record, the Board may consider and take possible action to identify the conditions, including the time frame, required increase in combined storage level, and potential limitations under which interruptible stored water supplies could be made available in that crop season.

#### 4.3.3. Allocation of interruptible stored water among the four downstream irrigation operations

Interruptible stored water is allocated to the individual irrigation operations based on the historic demands for such water by the operations, after taking into account the amount of run-of-river supply, if any, that the operation can rely on.

Interruptible stored water is allocated to the Garwood irrigation operation based on specific contract obligations. The Garwood run-of-river water right is one of the most senior rights in the basin, and is senior to water rights associated with the other irrigation operations. Consequently, run-of-river supply is expected to meet most of the demands associated with the Garwood operation under typical circumstances. The demand for interruptible stored water for Garwood, and the amount of interruptible stored water to be allocated to Garwood will be determined consistent with the Garwood Purchase Agreement.<sup>3</sup>

Pierce Ranch has an interruptible contract with LCRA providing for a maximum of 20,000 acre-feet of interruptible stored water on a five-year rolling average, with a one-year maximum of 30,000 acre-feet.<sup>4</sup> Those maximum values apply when combined storage is above the upper trigger points for first and second crop (1.4 and 1.55 MAF, respectively). The interruptible stored water commitment will be proportionally reduced consistent with the overall reductions in interruptible stored water to all irrigation operations when combined storage falls below those initial trigger points. The actual amounts of interruptible stored water needed for Pierce Ranch will vary each year due to the five-year averaging approach. LCRA retains the right to meet its commitment to Pierce Ranch from any source available to LCRA and is not obligated to use only stored water. Indeed, LCRA may rely on run-of-river supplies authorized for diversion at the Pierce Ranch diversion point in lieu of releasing interruptible stored water when that water is not otherwise needed to meet firm commitments.

The Gulf Coast and Lakeside irrigation operations typically divert significantly larger amounts of interruptible stored water than the Garwood and Pierce Ranch irrigation operations. Consistent with the historic reliance of these operations on interruptible stored water, after interruptible stored water is allocated to Garwood and Pierce Ranch, the remaining amount will be split evenly between the Gulf Coast and Lakeside operations.

#### 4.3.4. Allocation of run-of-river supplies to the downstream irrigation operations

The allocation of run-of-river supplies to the downstream irrigation operations is based on prior agreements and the relative priority of the Garwood, Gulf Coast and Lakeside water rights. Run-of-river supply assumed to be available within each crop season (first or second crop) will be allocated to the Garwood irrigation operation first because of the senior priority of the Garwood water right. For purposes of determining available supply prior to the crop season, Pierce Ranch will be allocated only interruptible stored water based on its contract, even if some portion of its needs have been or may be met with run-of-river supply. The Gulf Coast water right is junior to the Garwood right but senior to the Lakeside water right. Consequently, consistent with recent availability under such rights, the remaining run-of-river water after Garwood will be split such that the Gulf Coast operation is allocated 80 percent and the Lakeside operation is allocated 20 percent of the remaining assumed quantity. Tables 4-1 and 4-2 list the current assumed run-of-river availability for each irrigation operation for the interim and year 2020 demand phases, respectively. The dates used for making the determination of assumed run-of-river availability will be the same as those established in Section 4.3.2.1 for the determination of interruptible stored water availability. These amounts are applicable only during normal conditions and could vary as a result of LCRA Board action under a dry weather or wet weather exception. (See Section 4.4.) The overall run-of-river water availability for the year 2020 demand phase is reduced for the Gulf Coast and Lakeside operations due to the increased demands of the City of Austin, whose water right has access to run-of-river supplies after Garwood, but before Gulf Coast and Lakeside.

**Table 4-1. Assumed Quantity of Run-of-River Water for the Interim Demand Phase**

Storage Level	Garwood (ac-ft)	Gulf Coast (ac-ft)	Lakeside (ac-ft)	Total (ac-ft)
<b>First Crop</b>				
>1.4 MAF	66,500	42,800	10,700	120,000
1.399 - 1.0 MAF	63,000	29,600	7,400	100,000
0.999 - 0.650 MAF	59,500	24,400	6,100	90,000
<b>Second Crop</b>				
> 1.55 MAF	28,500	21,200	5,300	55,000
1.549 - 1.0 MAF	27,000	14,400	3,600	45,000
0.999 - 0.900 MAF	25,500	7,600	1,900	35,000

**Table 4-2. Assumed Quantity of Run-of-River Water for the Year 2020 Demand Phase**

Storage Level	Garwood (ac-ft)	Gulf Coast (ac-ft)	Lakeside (ac-ft)	Total (ac-ft)
First Crop				
>1.4 MAF	66,500	34,800	8,700	110,000
1.399 - 1.0 MAF	63,000	21,600	5,400	90,000
0.999 - 0.650 MAF	59,500	16,400	4,100	80,000
Second Crop				
> 1.55 MAF	28,500	16,400	4,100	49,000
1.549 - 1.30 MAF	27,000	10,000	2,500	39,500
1.299 – 1.20 MAF	25,500	3,600	900	30,000

#### 4.3.5. Total assumed supply available for contracting in the irrigation operations

The total amount of water available to each irrigation operation will be the combination of the allocated amount of interruptible stored water, as described in Section 4.3.3, and the allocated amount of assumed run-of-river quantities in Section 4.3.4 for either first crop or second crop season. This quantity represents the total amount assumed to be available at the irrigation operation's diversion point and would be committed for supply to each irrigation operation for the upcoming crop (first or second). This quantity is subject to cutoff any time during the crop season consistent with this WMP and interruptible agricultural contracts, including any special contract terms and conditions that control supply to Garwood and Pierce. The determination of the available amounts of water available for each irrigation operation will be made by LCRA's General Manager prior to the crop season for which the water will be available (first or second) and shared with the agricultural users within each irrigation operation in advance of the upcoming crop season.

#### 4.3.6. Determination of irrigable acreage within LCRA irrigation operations

Through its annual contracting process in the Garwood, Gulf Coast and Lakeside irrigation operations, LCRA will, at the beginning of each crop season, contract to provide irrigation water up to a maximum amount of acreage consistent with the limits of the available allocated water supplies. The irrigable acreage will be calculated from the amount of water determined to be available for diversion for each irrigation operation for that crop season.

Since a portion of the water that is diverted from the river is lost in delivery through the canal system, system delivery losses will be deducted in determining the total amount of water available for on-farm use. System delivery losses will be estimated using the average of system delivery losses within the past five years for each individual irrigation operation.

On-farm duty is a measure of the amount of water used to irrigate an acre of land (in acre-feet/acre) measured at the point of delivery. On-farm duty varies by type of crop, weather conditions and for each of the operations. LCRA will maintain records of water use by field on an annual basis. For purposes of calculating irrigable acreage, LCRA will use the second highest on-farm water duty by crop category over the last five years within each irrigation operation.

Irrigable acreage commitments will be calculated based on the following general equation:

$$\text{Irrigable Acreage} = \frac{\text{Total Water Supply at River Diversion Point} * (1 - \text{System Delivery Loss \%})}{\text{On Farm Water Duty}}$$

For example, if LCRA commits to make 70,000 acre-feet of water available for first crop diversion to an irrigation operation, system delivery losses are estimated to be 20 percent and on-farm duty is assumed to be 3 acre-feet/acre, then the maximum commitment on irrigable acreage will be 20,000 acres for first crop. The general equation above is for illustration purposes only and will need to be adjusted or modified for each operation due to the variability in cropping patterns and crops grown within each operation.

#### 4.3.7. Allocation of water to individual customers within LCRA irrigation operations

LCRA does not operate the canal system or enter into contracts with individual farmers associated with Pierce Ranch. Pierce Ranch will determine how water will be allocated within its own operation. Within each LCRA irrigation operation (Lakeside, Garwood and Gulf Coast), each customer's average base acreage history will be determined based on an averaging period. The current averaging periods are as follows: Garwood – five years; Gulf Coast – two years; and Lakeside – six years.

Within the Lakeside and Garwood irrigation operations, the base acreage history will be based upon the lands irrigated historically. A customer will not be allowed to receive water to irrigate lands in a curtailment year unless those lands were previously irrigated by that customer. One exception is if the current owner of the land that contributed to the base acreage history grants express written consent for the history to follow the customer rather than the specific tract of land. Such consent must be provided to LCRA with the customer's request for water for an upcoming crop season (first or second). If a customer no longer farms land that has a history of being farmed, that history will be credited to the current landowner or a successor tenant farmer unless the landowner has granted consent for such base acreage to follow the customer to other lands, as described above.

Within the Gulf Coast irrigation operation, the base acreage history will follow the LCRA customer, and not be restricted to a particular tract of land.

Allocation of water to the various users within the irrigation operations will be based on the amount of irrigated acreage on each tract of land. This irrigated acreage will be determined by accounting for established crop rotations during the defined averaging period and include only those years during that same period that water was used on the tract of land. Irrigation operations personnel will maintain this information for each irrigated tract of land. Separate base acreage histories will be maintained for the various crop types. During periods of curtailment, irrigation customer contracts will be limited to the base acreage as determined by the method described above and any reductions necessary will be made from this base acreage.

Water allocation among individual users within individual operations is not a property right and there are no procedures or policies that allow for individual users to obtain that right or to

transfer an allocation to another user. All water available will be allocated on a pro rata basis as described above, which is consistent with state law governing pro rata curtailment.

#### 4.3.8. Variances

Within each LCRA irrigation operation, the LCRA General Manager, after consultation with the operation's advisory committee, may adjust the averaging period for determining base acreages within the operation to account for established field rotations, changes in management practices, and other relevant factors.

#### 4.3.9. Enforcement

All LCRA interruptible stored water contracts include a provision requiring that, in cases of a shortage of water resulting from drought, the water will be distributed in accordance with LCRA's WMP and Texas Water Code section 11.039. Interruptible stored water customers within the irrigation operations failing to comply with the allocation requirements (curtailment plan) are subject to surcharges or excess use rates as set by the LCRA Board for water use in excess of the customer's per-acre duty. They may also be subject to civil action to enjoin them for breach of contract. Customers failing to comply with contractual requirements to prevent the waste of water are also subject to denial of water until such time as the failure is corrected.

### 4.4. EXCEPTIONS TO THE ALLOCATION PROCEDURES FOR THE IRRIGATION OPERATIONS

#### 4.4.1. Exceptions to standard curtailment procedures for the downstream irrigation operations under certain severe drought conditions

Notwithstanding the process set out in this Section, the LCRA reserves the right, at all times, to:

- take immediate action, consistent with state law, to respond to drought or any emergency condition threatening its water supply, and
- pursue any relief it deems appropriate with the Texas Commission on Environmental Quality (TCEQ) to deviate from or amend any of the provisions of this Water Management Plan (WMP).

During the development of this update to the WMP, an on-going drought event was in progress that had the potential to be more severe than droughts of similar duration and intensity contained in the historic period (1940-2009) used in the development and evaluation of this WMP update. Due to the intensity of this drought event, in October 2011, LCRA sought emergency relief from the TCEQ to deviate from the 2010 WMP with respect to the interruptible stored water curtailment procedures for supply of the downstream irrigation operations. This WMP update now provides LCRA the express authority to deviate, consistent with the provisions of this Section, from the curtailment procedures set out in Section 4.3 without TCEQ approval, when specified extreme dry weather conditions exist. This deviation is intended to provide for quick, rational, adaptive responses to drought conditions that were not evaluated in the development of this updated WMP. This authorization does not include authority to deviate from aspects of the WMP other than the interruptible stored and run of river water curtailment procedures for the

downstream irrigation operations. The circumstances and conditions under which this authority may be exercised are specified below.

The LCRA Board of Directors shall consider taking action, and may take action, after receiving and considering public comment, to deviate from the applicable interruptible stored and run of river water curtailment procedures for the downstream irrigation operations as described in Section 4.3 of this WMP (the “Standard Curtailment Procedures”), without seeking further TCEQ authorization, if each of the following Criteria for Potentially Deviating from the Standard Curtailment Procedures are met:

1. the inflow criteria for declaration of Drought Worse than the Drought of Record has been met;
2. the meteorological forecast from the National Oceanic Atmospheric Administration’s National Weather Service for the period through the upcoming irrigation season forecasts below normal precipitation in the majority of the watershed above the Highland Lakes;
3. the drought duration criteria for declaration of a Drought Worse than the Drought of Record has been met or has a reasonable likelihood of being met before or during the upcoming irrigation season; and
4. the combined storage criteria for declaration of a Drought Worse than the Drought of Record has a reasonable likelihood of being met before or during the upcoming irrigation season.

For purposes of evaluating whether criteria 3 and 4, above, are met any projections shall be limited to a time-horizon of six months.

If the Board makes a finding that the Criteria for Potentially Deviating from the Standard Curtailment Procedures have been met, the Board may take action to deviate from such procedures and establish “Modified Curtailment Levels and Procedures” in accordance with the following provisions.

1. For first crop, the Board finding regarding the potential to deviate from the Standard Curtailment Procedures, and any action to establish Modified Curtailment Levels and Procedures for making water available shall occur no earlier than at the October Board meeting and no later than at the February Board meeting.
2. For second crop, the Board finding regarding the potential to deviate from the Standard Curtailment Procedures, and any action to establish Modified Curtailment Levels and Procedures for making water available shall occur no earlier than at the February Board meeting and no later than at the June Board meeting.
3. If the Board acts to establish Modified Curtailment Levels and Procedures:
  - a. The Modified Curtailment Levels and Procedures shall make no more interruptible stored and run of river water available for use in the downstream irrigation operations than would be made available under the applicable Standard Curtailment Procedures;
  - b. The Modified Curtailment Levels and Procedures may rely on combined storage in lakes Buchanan and Travis on a date no earlier than March 1 for purposes of determining the amount of interruptible stored and run of river water to be made available for first crop and a date no earlier than August 1 for purposes of

determining the amount of interruptible stored and run of river water to be made available for second crop;

- c. The Modified Curtailment Levels and Procedures shall include provisions for promptly reinstating the applicable Standard Curtailment Procedures or for responding to improved conditions;
- d. Modified Curtailment Levels and Procedures shall only be in effect for the immediate upcoming crop season (first or second) after the Criteria are determined to be met. If the Board finds that criteria specified above for deviating from the curtailment procedures in Section 4.3 also are met prior to any subsequent crop season, the Board may take action at that time to deviate from the Standard Criteria and Procedures and establish Modified Curtailment Levels and Procedures for that subsequent crop season in accordance with this Section 4.4.1.

LCRA shall promptly inform TCEQ if it establishes Modified Curtailment Levels and Procedures pursuant to this Section and shall promptly reinstate the Standard Curtailment Procedures if the TCEQ issues an order directing LCRA to reinstate the Standard Curtailment Procedures.

#### 4.4.2. Exceptions to standard allocation procedures for the Gulf Coast Irrigation Division under certain wet conditions

In the event of certain combined storage and wetter than normal weather forecast conditions, LCRA may allocate an additional amount of run-of-river water to the Gulf Coast Irrigation Division over and above the amount described in Section 4.3.4. The LCRA Board of Directors shall consider taking action, and may take action, after receiving and considering public comment, to deviate from the amount of run-of-river water assumed to be available in the allocation procedures for the Gulf Coast Irrigation Division as described in Section 4.3.4 without further TCEQ action subject to the following conditions and limitations:

- 1. The Board must find that the meteorological forecast from the National Oceanic Atmospheric Administration's National Weather Service for the upcoming irrigation season forecasts above normal precipitation in the majority of the Lower Colorado River basin including the watershed above and below the Highland Lakes.
- 2. The Board finding regarding the potential to allocate additional run-of-river water for the Gulf Coast Irrigation Division and any action to allocate such additional water shall occur no earlier than at the January Board meeting and no later than at the March Board meeting and will be based on one of the following conditions:
  - a. If the combined storage on March 1 is below 1.4 million acre-feet, no additional water shall be allocated to the Gulf Coast Irrigation Division.
  - b. If the combined storage on March 1 is between 1.4 million acre-feet and 1.75 million acre-feet:
    - i. If the interim curtailment procedures are in effect, the Board may allocate up to 10,000 acre-feet of additional run-of-river to the Gulf Coast Irrigation Division during the first crop season in addition to the amount described in Section 4.3.4; and
    - ii. If the year 2020 curtailment procedures are in effect, no additional run-of-river water shall be allocated.



- c. If the combined storage on March 1 is above 1.75 million acre-feet, the Board may allocate up to 25,000 acre-feet of additional run-of-river to the Gulf Coast Irrigation Division during the first crop season in addition to the amount described in Section 4.3.4.
3. If, for a crop season in which the allocation was increased based upon provision 2 b or c above, the total diversions of interruptible stored water at the Gulf Coast Irrigation Division exceed the interruptible stored water allocation for that season as determined under Section 4.3.3, as a result of application of provision 2 b or c above, then water made available to the Gulf Coast Irrigation Division in the subsequent year will be reduced. Specifically, not later than during the first crop irrigation season in the next year in which interruptible stored water is available, the allocation of interruptible stored water to the Gulf Coast Irrigation Operation shall be reduced by the amount of excess interruptible stored water diversion provided in the prior year in accordance with provision 2 b or c above (water taken out of storage or storable inflows). If the combined storage in lakes Buchanan and Travis has been at its full capacity as described in Section 4.8 since the excess diversions of interruptible stored water occurred, then no reduction in interruptible stored shall occur in the following first crop season.
4. Notwithstanding this Section 4.4.2, the annual cap on interruptible stored water for contracting as described in Section 4.2.2.2 still applies.
5. The additional allocation of run-of-river water shall only be in effect for the immediate upcoming first crop season for which the conditions and limitations are determined to be met. If the Board finds the conditions and limitations for deviating from the allocation procedures in Section 4.3.4 also are met prior to any subsequent first crop season, the Board may take action at that time to deviate from allocation procedures for that crop season.

#### 4.5. CURTAILMENT PROCEDURES FOR ENVIRONMENTAL FLOWS IN LOWER COLORADO RIVER BASIN

##### 4.5.1. Helping meet environmental flow needs with firm and interruptible stored water

Under this WMP, as in past WMPs, a combination of firm and interruptible stored water is provided to help meet environmental flow needs. LCRA has previously set aside 33,440 acre-feet per year of its firm supply from lakes Buchanan and Travis for environmental flow purposes. No increase in that amount is included in this WMP. In the event of a pro rata curtailment of firm water supplies, the applicable instream flow and bay and estuary inflow criteria will be subject to the same percentage reduction as is imposed on LCRA's firm water customers.

This WMP reflects improvements to the operational procedures that will be used to help meet these needs based on more recent scientific studies. The applicable environmental flow criteria under this WMP can change during the year, similar to the determination of agricultural water based on separate dates for first crop and for second crop. The environmental flow criteria in place from March through June are based on the combined storage on Jan. 1, and the environmental flow criteria in place from July through the following February are based on the combined storage on June 1. This represents a change from prior WMPs in which the

environmental flow criteria for the entire year were based on Jan. 1 combined storage. Other modifications to the manner in which water for environmental purposes is provided and tracked are set forth in more detail below.

#### 4.5.2. Curtailment of water for instream flows

This WMP revision includes up to three levels of instream flow targets, located at four streamflow gauging station locations (Austin, Bastrop, Columbus and Wharton) as first presented in Table 2-4 and repeated here as Table 4-3. For this WMP revision, the Wharton gauge location has been added. Additionally, levels of instream flows have changed from “critical” and “target” to “Subsistence,” “Base-Dry” and “Base-Average” based upon recent studies.

When providing water under this WMP to help meet instream flows, the water available to meet Base-Average and Base-Dry is limited to the storable inflows to lakes Buchanan and Travis. In addition to storable inflows, previously stored water will be released as necessary to maintain Subsistence flows. Tables 4-4 and 4-5 present the applicable instream flow criteria based on combined storage in lakes Buchanan and Travis for the interim and 2020 demand phases, respectively. In the event of a pro rata curtailment of firm supplies, the applicable instream flow criteria will be subject to the same percentage reduction as imposed on LCRA’s firm water customers.

**Table 4-3. Subsistence and Base Flow Recommendations by Gauge (cubic feet per second)**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Austin												
Subsistence	50	50	50	50	50	50	50	50	50	50	50	50
Bastrop												
Subsistence	208	274	274	184	275	202	137	123	123	127	180	186
Base-Dry	313	317	274	287	579	418	347	194	236	245	283	311
Base- Average	433	497	497	635	824	733	610	381	423	433	424	450
Columbus												
Subsistence	340	375	375	299	425	534	342	190	279	190	202	301
Base-Dry	487	590	525	554	966	967	570	310	405	356	480	464
Base-Average	828	895	1,020	977	1,316	1,440	895	516	610	741	755	737
Wharton												
Subsistence	315	303	204	270	304	371	212	107	188	147	173	202
Base-Dry	492	597	531	561	985	984	577	314	410	360	486	470
Base-Average	838	906	1,036	1,011	1,397	1,512	906	522	617	749	764	746

**Table 4-4. Instream Flow Triggers and Flow Levels for Interim and 2020 Demand Phases**

When Combined Storage is...	On this date...	Instream Flow Level
Above 1.96 MAF	Jan. 1 or June 1	Base-Average
Between 1.90 and 1.96 MAF	Jan. 1 or June 1	Base-Dry
Less than 1.90 MAF	Jan. 1 or June 1	Subsistence

For purposes of this WMP revision, the Subsistence and Base Flow targets for gauges other than the Austin gauge, are daily (or daily average) flow targets. The Subsistence target at Austin is a minimum (or instantaneous) flow requirement. Furthermore, for the Bastrop gauge, the following minimum flow requirements apply:

- During those times when Base-Average criteria are in effect and inflows are sufficient to meet Base-Average at Bastrop on a daily average basis, the minimum flow criteria shall be the Base-Dry criteria for the given month.
- During those times when Base-Dry criteria are in effect and inflows are sufficient to meet Base-Dry at Bastrop on a daily average basis, the minimum flow criteria shall be the Subsistence criteria for the given month.
- During those times that Subsistence criteria are in effect, releases shall be scheduled such that the minimum flow does not drop below 70 percent of Subsistence.

In order to help meet the instream flow targets in the lower Colorado River, LCRA will schedule releases of inflows in amounts sufficient to meet the applicable targets, to the extent of storable inflows or, for Subsistence, using previously stored water. In scheduling releases, LCRA will rely on best available data sources, including but not limited to: measurements of rainfall and water levels in streams and reservoirs; flow ratings for streams, canals, hydroelectric turbines, spillways, floodgates, and pumps; elevation/area/capacity ratings for reservoirs; model results for predicted storm runoff and ungauged gains or losses of flow along the Colorado River; simulated routing and attenuation of flows along channels and through reservoirs; effluent discharge as reported by wastewater treatment plant operators, and; scheduled and actual pumping as reported by major diverters.

By scheduling releases in this manner, LCRA will meet its obligation under the Water Management Plan. In rare instances, LCRA's ability to meet the flow targets, despite reasonable efforts to do so, may be impaired by unavoidable constraints such as unforeseen diversions, unforeseen changes in flow conditions downstream, unforeseen operations at Longhorn Dam, and adjustments to gauges or flow ratings. LCRA shall operate in such a manner that flows at any applicable gauge do not deviate below the applicable targets for that gauge on more than 18 days in any calendar year. Furthermore, to the extent that the deviation is a result of inaccuracies in LCRA's estimates of downstream diversions by LCRA operations, downstream contributing inflows, downstream return flows, or the effects of routing and attenuation as releases pass downstream, the collective impact of such constraints may not be relied upon to excuse a deviation of more than a 15 percent or 50 cfs, whichever is greater, below applicable targets on any individual day. In the event that the deviation is caused by events outside of LCRA's reasonable control – such as operations at Longhorn Dam, ERCOT requirements, a change in rating at a gauge, or diversions by others – such deviation is not subject to the 15 percent or 50 cfs limitation. Furthermore, in the event of flow data that indicate a deviation has occurred, and after inspection of relevant data and/or the gauge itself to determine the reasonableness of such data, if LCRA determines that the flow data was inaccurate and that the actual flow rate was above the applicable threshold requirement, the event shall not be deemed to be a deviation. Additionally, in the event that storable inflows are sufficient to meet a Base-Flow or Base-Dry flow target for a given day, but not a consecutive day, or that applicable targets change on the

first day of a month, compliance with applicable targets at gauges where the time to deliver water from Miller Dam to such gauge is not an even multiple of 24-hours may be determined over continuous 24-hour periods other than midnight-to-midnight. In the event of an impairment on an individual day or days, LCRA will schedule releases over the subsequent days to ensure that the average flow for any consecutive 10-day period that begins with the day of any such impairment does not fall below the applicable instream flow target, subject to the availability of storable inflows, or for Subsistence, the availability of a combination of storable inflows and previously stored water.

Although LCRA will not manage water in the lower basin to specifically provide for pulse flows as part of this WMP, LCRA will monitor pulse flows in the lower river basin during the time period when this WMP update is in effect.

#### 4.5.3. Curtailment of water for freshwater inflows to Matagorda Bay

The 2010 WMP included three levels (critical, intermediate and target) of freshwater inflow criteria. This WMP includes five levels based upon the Matagorda Bay Health Evaluation (MBHE) study.

For purposes of this WMP, new “Operational Criteria” have been developed to help meet the range of freshwater inflow needs from the Colorado River associated with the MBHE study. Instead of the monthly requirement that has been used in prior WMPs, the MBHE three-month “spring” and “fall” and six-month “intervening” flow totals for a given inflow category have been converted into equivalent two-month Operational Criteria (OP 1-4) as first presented in Table 2-8 and repeated here in Table 4-5. (See Section 2.4.2 for further explanation of these criteria.) At the end of each month, to the extent that storable inflows are available, such inflows will be provided as necessary to meet the two-month Operational Criteria. In all months, the “Threshold” level of 15,000 acre-feet per month will also be provided to the extent of storable inflows. In the event of a pro rata curtailment of firm supplies, the applicable inflow criteria (including the Threshold criteria) will be subject to the same percentage reduction as imposed on LCRA’s firm water customers.

**Table 4-5. Operational Criteria for Colorado River Inflows to Matagorda Bay**

Inflow Category	Two-Month Operational Criteria (ac-ft) applicable in the individual months			Monthly (ac-ft)
	Spring March-June	Fall July-Oct	Intervening Nov-Feb	-
OP-4	289,000	205,000	133,000	-
OP-3	164,000	117,000	76,000	-
OP-2	112,000	80,000	52,000	-
OP-1	76,000	54,000	35,000	-
Threshold	-	-	-	15,000

When providing water under this WMP to help meet freshwater inflow needs, the water available will be limited to the storable inflows to lakes Buchanan and Travis. Tables 4-6 and 4-7 present the applicable freshwater inflow criteria based on combined storage in lakes Buchanan and Travis for the interim and 2020 demand phases, respectively.

**Table 4-6. Interim Demand Phase Freshwater Inflow Triggers and Flow Levels**

When Combined Storage is...	On this date...	Freshwater Inflow Criteria
Greater than 1.95 MAF	Jan. 1 or June 1	OP – 4
Less than 1.95 MAF	Jan. 1 or June 1	OP – 3
Less than 1.50 MAF	Jan. 1 or June 1	OP – 2
Less than 1.30 MAF	Jan. 1 or June 1	OP – 1
Less than 1.00 MAF	Jan. 1 or June 1	Threshold Only

**Table 4-7. 2020 Demand Phase Freshwater Inflow Triggers and Flow Levels**

When Combined Storage is...	On this date...	Freshwater Inflow Criteria
Greater than 1.95 MAF	Jan. 1 or June 1	OP – 4
Less than 1.95 MAF	Jan. 1 or June 1	OP – 3
Less than 1.80 MAF	Jan. 1 or June 1	OP – 2
Less than 1.70 MAF	Jan. 1 or June 1	OP – 1
Less than 1.00 MAF	Jan. 1 or June 1	Threshold Only

#### 4.6. CURTAILMENT PROCEDURES FOR INTERRUPTIBLE STORED WATER DEMANDS OTHER THAN THE DOWNSTREAM IRRIGATION OPERATIONS

LCRA will limit additional sales or commitments of interruptible stored water, other than for the four downstream irrigation operations, based on the combined volume of water in lakes Buchanan and Travis at certain times of the year. Sales of water in this category will be limited to not more than a combined total of 4,000 acre-feet per year as follows:

- If combined storage on Jan. 1 is greater than 1.9 MAF, up to 2,000 acre-feet will be made available for the period from Jan. 1 through June 30.
- If combined storage on June 1 is greater than 1.9 MAF, up to 2,000 acre-feet will be made available for the period from July 1 through Dec. 31.

Within two weeks of the Jan. 1 and June 1 trigger dates, the LCRA General Manager will notify, in writing, each holder of a contract under this provision of the availability of supply for the six months following the trigger dates.

LCRA will not enter into any new contracts or extend any existing contracts for this category of water sales for a term beyond Dec. 31, 2018. As of Jan. 1, 2019, this category of water supply will be eliminated.

## 4.7. CURTAILMENT OF FIRM WATER DEMANDS

### 4.7.1. Introduction

Pursuant to its water rights for lakes Buchanan and Travis, LCRA must follow water supply allocation procedures to ensure that there is sufficient stored water to meet firm demands during a repeat of the Drought of Record. This WMP includes procedures intended to ensure that firm demands can be met without shortage through year 2020 under a repeat of the Drought of Record.

LCRA cannot determine with absolute certainty whether a particular drought event will be more or less severe than the Drought of Record until the event has concluded. Therefore, LCRA will engage its firm customers and seek voluntary reductions of firm demands from its customers in the early stages of a drought, as more specifically described below.

Consistent with state law, LCRA cannot invoke mandatory curtailments of firm water demand unless a particular drought is declared to be a Drought Worse than the Drought of Record, or some other water emergency exists that drastically reduces the available firm water supply. LCRA has developed a “drought monitoring procedure” for identifying when a drought may become worse than the Drought of Record for the Highland Lakes watershed. (See Section 4.8.)

### 4.7.2. LCRA drought response measures for firm water demands, including firm commitments for environmental flows

LCRA’s drought response measures for firm water demands are as follows:

- LCRA will encourage its firm water customers to implement long-term water conservation measures year-round to meet the goals included in their water conservation plans. LCRA will, as needed, implement a public awareness program on water use and conservation.
- Drought Contingency Plan, Stage 1. If the total combined storage in lakes Buchanan and Travis drops below 1.4 MAF and interruptible stored water supplies to the irrigation operations are being curtailed, LCRA will request its firm water customers to implement drought response measures in their individual drought contingency plans with a target demand reduction goal of 5 percent. In this stage, at a minimum, firm water customers should implement voluntary drought response measures. If the combined storage in lakes Buchanan and Travis subsequently increases, the request will be withdrawn on a schedule determined by the LCRA Board.
- Drought Contingency Plan, Stage 2. If the total combined storage in lakes Buchanan and Travis drops below 900,000 acre-feet and interruptible stored water supplies to the irrigation operations are being curtailed, LCRA will request its firm customers to implement additional drought response measures in their individual drought contingency plans with a target demand reduction goal of 10 to 20 percent. In this stage, firm customers should implement mandatory water use reduction measures. At this stage LCRA will also implement an aggressive public information campaign to provide up-to-date information on water supply conditions and promote voluntary action to reduce

water use. If the combined storage in lakes Buchanan and Travis subsequently increases, the request will be withdrawn or replaced by Stage 1 measures on a schedule determined by the LCRA Board.

- Drought Contingency Plan, Stage 3. If the LCRA Board of Directors declares a Drought Worse than the Drought of Record, LCRA will curtail and distribute the available supply of stored water among its firm water supply customers and firm environmental flow commitments on a pro rata basis according to the amount of stored water to which they are legally entitled consistent with the Pro Rata Plan for Firm Water Demands previously approved by TCEQ. (See Appendix C-7.) All uses of interruptible stored water will be cut off prior to and during any mandatory pro rata curtailment of firm water supplies. The initial curtailment of firm demands under pro rata will be 20 percent, unless the LCRA Board determines an alternative percentage reduction prior to or at the time of a declaration of Drought Worse than Drought of Record. LCRA's firm water contract rules<sup>5</sup> include specific procedures and requirements related to a pro rata curtailment of firm demands. If the combined storage in lakes Buchanan and Travis continues to decrease after the declaration of a Drought Worse than Drought of Record, the LCRA Board may increase the mandatory pro rata curtailment percentage. In the event that a declaration of a Drought Worse than Drought of Record is cancelled, a mandatory pro rata curtailment would be lifted. The LCRA Board may also set additional criteria for ending pro rata curtailment, such as combined storage increasing to a given level.

#### 4.7.3. Monitoring and enforcement

LCRA will monitor firm customers' compliance with LCRA's Drought Contingency Plan requirements. Monitoring and enforcement of water-use restrictions at the end-user level generally will be the customers' responsibility. Customers who exceed their allotted supply during a pro rata curtailment will be subject to excess use rates or surcharges, to be specified by the LCRA Board, in addition to LCRA's firm water rate.

#### 4.7.4. Variances to firm water pro rata curtailment

LCRA's General Manager may, in writing, grant a temporary variance to the pro rata water allocation requirement in Section 4.7.2 if it is determined that failure to grant such a variance would cause an emergency condition adversely affecting the public health, welfare or safety, and if one or more of the following conditions are met:

- 1) Compliance with the requirement cannot be technically accomplished during the duration of the water supply shortage or other condition for which the plan is in effect; and/or
- 2) Alternative methods can be implemented that will achieve the same level of reduction in water use.

Details regarding the procedures by which a customer may seek a variance are found in LCRA's firm water contract rules.

#### 4.7.5. Firm customer drought contingency plans

As part of its contracts, LCRA will continue to require its firm water customers to prepare and adopt a legally enforceable local drought contingency plan that specifies the actions to be taken to comply with this Drought Contingency Plan regarding the curtailment of firm supplies. Such plans should be developed pursuant to LCRA guidelines and submitted for LCRA review and acceptance within a reasonable time.

#### 4.7.6. Notification of TCEQ Executive Director

The LCRA General Manager will notify the TCEQ Executive Director of implementation of any mandatory provisions related to the supply of firm water.

### 4.8. DECLARATION AND CANCELLATION OF DROUGHT WORSE THAN DROUGHT OF RECORD

As discussed above, the WMP is designed so that LCRA can meet all firm demands through a repeat of the Drought of Record. If drought conditions reach a stage where an ongoing drought has a real likelihood of becoming a new Drought of Record, LCRA must cut off interruptible stored water and curtail firm demands to extend the supply for critical human needs. To measurably extend the supply, LCRA may need to take these actions before it is determined with absolute certainty that the drought is indeed a new Drought of Record. This section presents the conditions under which LCRA will respond to a severe drought by making a declaration of Drought Worse than Drought of Record (DWDOR). A DWDOR declaration would trigger action to cut off interruptible stored water and implement mandatory pro rata curtailment of firm demands. The criteria for making a DWDOR declaration represent circumstances that have not occurred in the historic period used in developing this WMP. However, even if the criteria are satisfied, there is still a possibility that the drought would not be a new Drought of Record. Thus, the declaration of a Drought Worse than Drought of Record is actually a declaration that a particular drought is *potentially* worse than the Drought of Record and warrants more significant response measures.

The LCRA Board of Directors will make a Drought Worse than Drought of Record declaration when the following three conditions are simultaneously met:

1. Drought duration of at least 24 consecutive months; and
2. Drought intensity greater than that of the Drought of Record as measured by inflows into the Highland Lakes; and
3. The combined storage in lakes Buchanan and Travis is less than 600,000 acre-feet.

Additionally, the LCRA Board of Directors will declare a DWDOR when a drought's duration is at least 10 years and the combined storage in lakes Buchanan and Travis is less than 600,000 acre-feet.



For purposes of measuring drought duration, the beginning of the drought is based on the last time lakes Buchanan and Travis were both full. For purposes of this declaration, full is defined when either of the following criteria is met:

- Combined storage is at or above 98 percent of the combined managed conservation storage. This managed conservation storage may vary based on seasonal operational guidelines or other constraints on storage; or
- Lakes Buchanan and Travis have each been at their respective managed conservation storage capacity within 30 days of each other.

For purposes of measuring drought intensity relative to the Drought of Record, the cumulative inflows since the beginning of the drought will be compared to a Drought of Record inflow envelope curve that reflects the cumulative inflows in the critical periods of the Drought of Record. The envelope curve consists of a uniform slope of 56,798 acre-feet per month for the first 62 months of the drought and a slope of 73,241 acre-feet per month for the remainder of the drought.

LCRA will cancel a DWDOR declaration if combined storage increases to 900,000 acre-feet or other cancellation criteria as established by the LCRA Board upon declaration of a DWDOR are met.

See Technical Paper A-6 found in Appendix A for additional information regarding the evaluations of historic period (1940-2009) droughts for comparisons to the Drought of Record.

#### 4.9. IMPACTS OF THE RECOMMENDED CURTAILMENT POLICIES UNDER THIS WMP

This section summarizes impacts of this WMP revision on various interests based on modeling simulations. It also provides comparisons to simulations of the 2010 WMP. It should be noted that the specific values presented in this section are based on model simulations that include many assumptions, including a repeat of historic hydrologic conditions through 2009. Actual observed conditions while this plan is in effect may vary.

##### 4.9.1. Firm water customers

All projected interim phase and 2020 level demands for firm water customers can be fully satisfied under a simulated repeat of hydrologic conditions during the historic period of 1940-2009, including during the Drought of Record and during short-term intense droughts experienced in recent decades. The minimum storage in the model simulations for this WMP revision was maintained in a range of 375,000 to 400,000 acre-feet, which represents an increase in the safety factor from 200,000 acre-feet in previous WMPs. This safety factor is intended to allow for one year of firm demands to be met under continued severe drought conditions. The largest firm water demand is for the City of Austin. In most years of the simulations, the majority of Austin's projected annual demand in 2020 of 203,880 acre-feet is met from run-of-river flows (about 93 percent on average) diverted under its senior water rights. Approximately 82 percent of the demand during the critical drought years in the 1947-1957 is estimated to be supplied by

these flows with the remainder supplied by firm stored water. These percentages could change in the future based on the availability of run-of-river flows in the watershed above Austin's diversion points.

#### 4.9.2. Agricultural customers in downstream irrigation operations

With the increase in projected firm water needs for 2020, there is less interruptible stored water supply from lakes Buchanan and Travis because firm water needs take priority over interruptible stored water uses. To avoid shortages to firm water users under this WMP, LCRA will reduce the availability of interruptible stored water supplies from lakes Buchanan and Travis as compared to what is available under the WMP approved in 2010. This reduction in supplies primarily impacts agriculture (irrigation).

This WMP revision includes curtailment procedures with various elements (such as the separate evaluation of supply for first and second crop, and a higher trigger for providing full supply) that are more restrictive on the supply of interruptible stored water for the downstream irrigation operations than the procedures in the 2010 WMP. As a result of these more restrictive curtailment procedures, the average percent of time that the projected full annual agricultural demands in the four downstream irrigation operations can be met is reduced from 98 percent to 88 percent over the simulation of the historic period (1940-2009) evaluated. The 2010 WMP provides sufficient supplemental stored water to meet 100 percent of first crop demands and 81 percent of second crop demands over the simulation of the 1940-2009 evaluation period. Under this WMP revision those percentages are reduced to 73 percent and 61 percent, respectively, over the evaluation period for the 2020 demand phase.

Agricultural users in the four downstream irrigation operations would be most affected during a repeat of the 10-year Drought of Record. In that period, the modeling analysis indicates that no interruptible stored water would be available for first crop in three of the 10 years and no interruptible stored water would be available for second crop in seven of the 10 years.

Of course, as noted previously, the actual interruptible stored water curtailments may differ from the values reflected in this simulation, depending on factors such as future hydrologic conditions and actual demands associated with firm and interruptible users.

#### 4.9.3. Environmental flows

Under simulations of this WMP revision, roughly the same amount of total stored water (firm and interruptible) will be made available specifically for environmental flow purposes as under the simulations of the 2010 WMP. During a repeat of the Drought of Record, simulations indicate that an annual average of about 46,187 acre-feet would be provided specifically for instream flows and Matagorda Bay under the 2020 curtailment procedures compared to 42,601 acre-feet under the 2010 WMP.

During the simulated repeat of the Drought of Record, there will be more curtailments and cutoffs of interruptible stored water under this WMP. As a result, less water would be flowing in the lower Colorado River to meet downstream agricultural demands, which means less of that

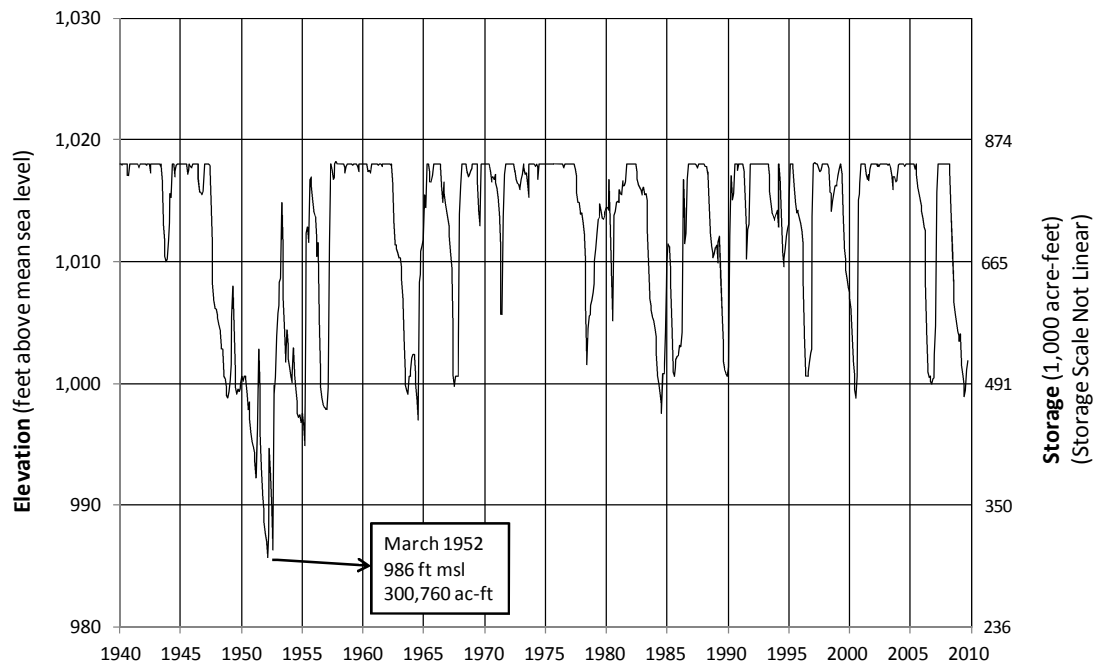
water is available to help meet environmental flow needs. Thus, dedicated releases for environmental flows are needed on a more frequent basis under simulations of this WMP revision. Furthermore, although the total amount of stored water specifically made available for environmental flow purposes is roughly the same for this WMP as the 2010 WMP, the average flow in the lower Colorado River and the average flow reaching Matagorda Bay is reduced as compared to the 2010 WMP. For a simulated repeat of the Drought of Record, the average annual flow of the Colorado River at Bay City is about 696,000 acre-feet under the 2020 curtailment procedures, compared to 766,000 acre-feet under the 2010 WMP. For a repeat of the 1940-2009 evaluation period, the simulated annual flow at Bay City averages about 1.566 million acre-feet under the 2020 curtailment procedures. This flow consists of dedicated releases of storable inflows to lakes Buchanan and Travis to help meet the range of freshwater inflow needs, dedicated releases to help meet a range of instream flow needs at several gauging locations below Longhorn Dam, releases made for downstream agricultural demands that were not diverted, and runoff originating below Lake Travis.

As mentioned in Section 4.5.1, LCRA is not recommending any changes to the level of firm commitment for environmental flows as part of this WMP. The current total firm water allocation of 33,440 acre-feet for environmental flow purposes represents about 8 percent of the total firm supply available from lakes Buchanan and Travis.

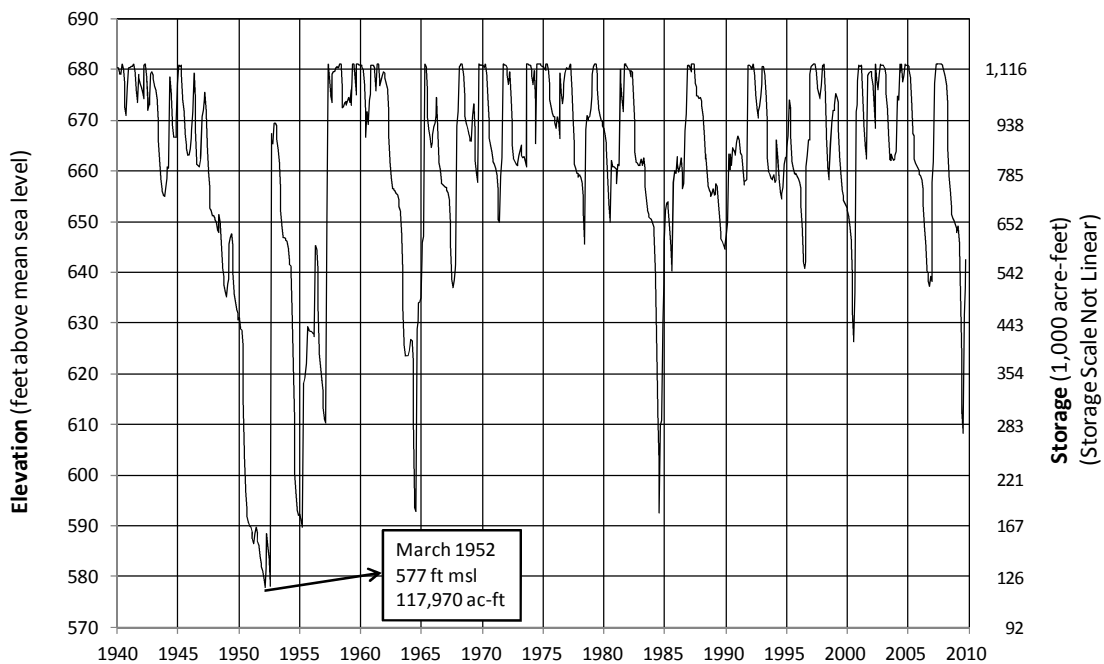
#### 4.9.4. Lake storage levels

The simulated lake water surface elevations and storage levels for each demand phase (Interim and 2020) are shown in Figures 4-3 through 4-6, for lakes Buchanan and Travis. The average lake water surface levels under the WAM simulations with the 2010 WMP are about 1013 feet msl on Lake Buchanan and 662 feet msl on Lake Travis. For comparison, the average lake water surface levels during the same simulation period (1940-2009) using the 2020 curtailment procedures would be lower at about 1,012 feet msl on Lake Buchanan and 659 feet msl on Lake Travis. The average lake water surface elevations using the 2020 curtailment procedures during the drought of record period hydrology of 1946-1957 are about 1,004 feet msl on Lake Buchanan, and 631 feet msl on Lake Travis. The minimum lake surface levels simulated using the 2020 curtailment procedures during the drought of record period hydrology of 1946-1957 are about 984 feet msl on Lake Buchanan, and 574 feet msl on Lake Travis.

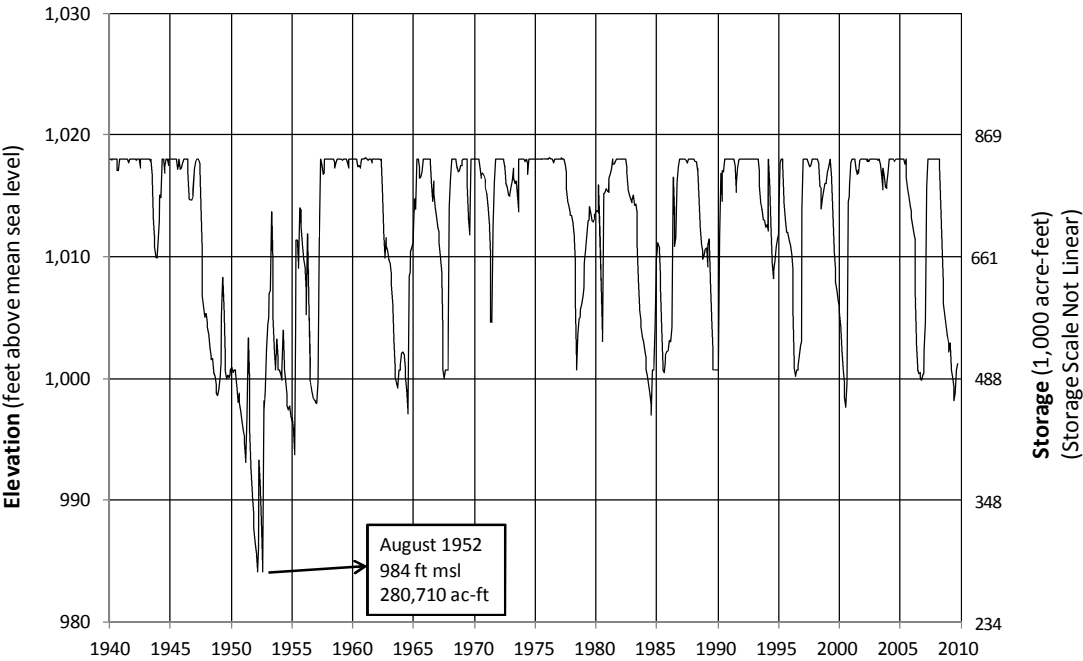
**Figure 4-3: Simulated Water Surface Levels and Storage for Lake Buchanan: Interim WAM**



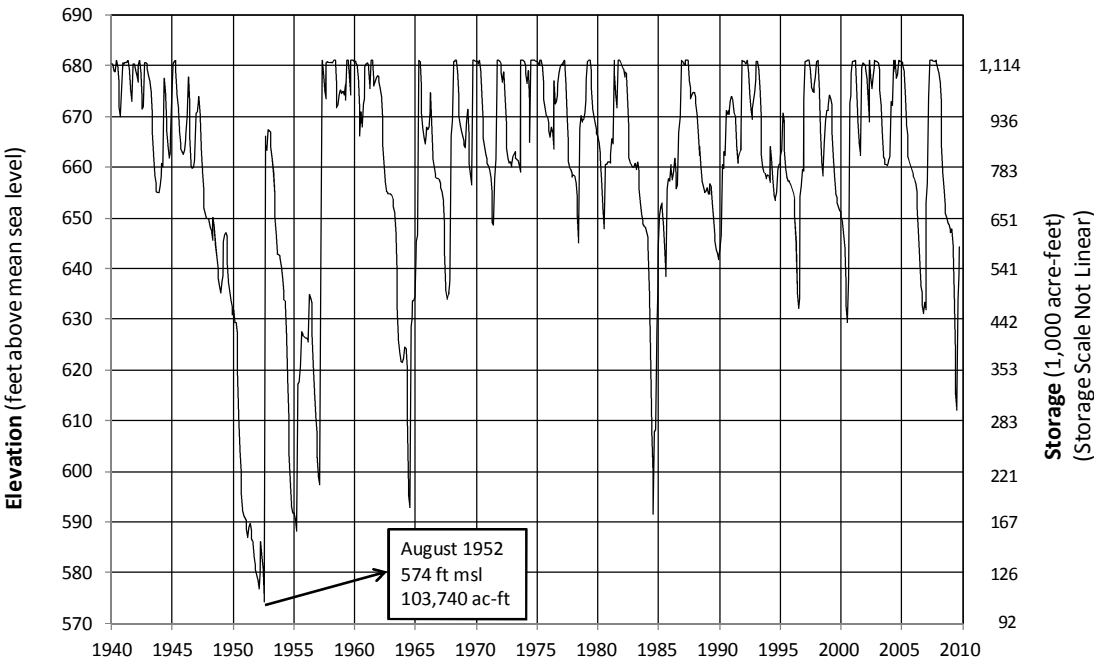
**Figure 4-4: Simulated Water Surface Levels and Storage for Lake Travis: Interim WAM**



**Figure 4-5: Simulated Water Surface Levels and Storage for Lake Buchanan: 2020 WAM**



**Figure 4-6: Simulated Water Surface Levels and Storage for Lake Travis: 2020 WAM**



#### 4.10 DROUGHT CONTINGENCY PLAN UPDATES

This chapter of the Water Management Plan incorporates LCRA's Drought Contingency Plans (DCPs) for its firm water customers, environmental flow needs, downstream irrigation operations and other interruptible stored water customers.

This chapter consists of Water Management Plan and Drought Contingency Plan elements. Elements of the Water Management Plan that are subject to TCEQ approval, including notice and the opportunity for a contested case hearing, are limited to those that relate to the allocation of water from lakes Buchanan and Travis between interruptible and firm uses. These include the determination of the amount of interruptible stored water available, environmental flow criteria and criteria for declaring a Drought Worse than Drought of Record.

Consistent with 30 Tex. Admin. Code Ch. 288, LCRA will review and update, as appropriate, in accordance with the schedule required by such rules, those portions of each of its Drought Contingency Plans that do not change the triggers, amount of curtailment of interruptible supply, or the triggers related to instream flows and bay and estuary inflows. As recognized by prior TCEQ orders, such changes do not constitute an amendment to the Water Management Plan requiring notice and an opportunity for contested case hearing, but must otherwise comply with the public notice requirements of Chapter 288 of the Commission's rules.

#### 4.11 ADMINISTRATION OF ALLOCATION PROCEDURES

LCRA Board action is required for the following actions under this Chapter:

- Shift from interim to 2020 curtailment procedures. (Section 4.2.)
- Establishing criteria for resuming supply of interruptible stored water within the same calendar year following a cutoff of first crop. (Section 4.3.2.5.)
- Establishing surcharges or excess use rates applicable to interruptible agricultural customers. (Section 4.3.10.)
- Deviation from standard curtailment procedures under a wet weather or dry weather exception. (Section 4.4.)
- Establishing criteria for lifting of firm demand Drought Contingency Plan stages. (Section 4.7.2.)
- Initiation of pro rata curtailment of firm demands, and determination of pro rata reduction percentages for firm demands. (Section 4.7.2.)
- Determination of surcharges or excess use rates applicable to firm water customers. (Section 4.7.3)
- Declaration of Drought Worse than Drought of Record (Section 4.8.)
- Establishing of additional criteria for cancellation of a declaration of Drought Worse than Drought of Record. (Section 4.8.)
- Updates to Drought Contingency Plan under TCEQ Chapter 288 rules. (Section 4.10.)

LCRA Board action is not required for actions under this chapter other than those itemized above. Acts not requiring Board action include, but are not limited to: determination of interruptible supply available consistent with the standard curtailment procedures, determination of applicable environmental flow criteria, and determination of interruptible stored water available to customers outside of the irrigation operations.

LCRA will notify the TCEQ within 30 days of the following:

- Board determination of a shift from the interim to 2020 curtailment procedures.
- Board declaration of Drought Worse than Drought of Record.
- Board action implementing pro rata curtailment of firm demands.
- Updates to its Drought Contingency Plan under TCEQ Chapter 288 rules.

In response, and/or in anticipation of the following actions, LCRA will carry out a public information campaign that is appropriate to the action:

- Any of the above items requiring Board action;
- Initiation or cancellation of firm water demand drought contingency stages.

Additionally, LCRA will communicate with its interruptible agricultural customers prior to the beginning of a crop season (first or second) regarding the potential supply available during the upcoming crop season.

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1. Pursuant to the certificates of adjudication for Lakes Buchanan and Travis, LCRA shall curtail the supply of interruptible water under such water rights to the extent necessary to allow LCRA to satisfy all firm demands. (Certificates of Adjudication Nos. 14-5478 and 14-5482, provision 2.B.(7).)
  2. See section 1.3 for the list of items to be addressed pursuant to the January 2010 TCEQ Order.
  3. Purchase Agreement by and Between Garwood Irrigation Company and LCRA, July 20, 1998.
  4. Agreement to Supply Interruptible Stored Water by and Between LCRA and Testamentary Trusts created under the Wills and Codicils of Lacy Withers Armour, deceased, and the Amended & Restated Laurance H. Armour, Jr. and Margot Boyd Armour 1989 Trust, May 23, 2000.
  5. The most current version of LCRA's water contract rules may be found at:  
<http://www.lcra.org/water/supply/contracts/index.html>

## **CHAPTER 5 RIVER OPERATIONS**

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### **5.1 INTRODUCTION**

LCRA operates the Colorado River and the Highland Lakes as a system to efficiently manage water supply and mitigate flood damage. To accomplish these goals, LCRA uses a number of tools and practices that it regularly updates. To manage its river operations, LCRA develops and maintains data acquisition systems, decision support models and standard operating guidelines and procedures. This chapter provides a general description of river operations as of January 2012.

These tools and practices are regularly updated and any references to specific tools and practices in this chapter does not bind LCRA to continue to use the specific tools and practices described herein, nor does it limit LCRA from using modified or additional tools and practices at any point.

Furthermore, LCRA may deviate from this general description of river operations to respond to emergency incidents, to accommodate requests for public events on a lake, to lower lakes below their normal operating range, to operate floodgates for testing and maintenance, or for other reasons. In the event of deviation from the general description contained in this chapter, LCRA will operate in a manner intended to minimize or avoid the risk of injury to life and property, and to conserve and protect water supply whenever reasonably possible.

### **5.2 DATA SOURCES**

LCRA maintains and operates a Hydro-meteorological Data Acquisition System (Hydromet) of about 265 gauges located throughout the lower Colorado River basin. The Hydromet gauges send water levels, rainfall and other weather data to LCRA computers every 15 minutes. Once stored on LCRA computers, the data can be validated, automatically shared with other partner agencies, and used to analyze the quantity and movement of water through the Colorado River basin and the Highland Lakes.

LCRA has executed an agreement with the U.S. Geological Survey (USGS) to share the maintenance and operation of 17 Hydromet gauges, and receives data from an additional 12



gauges that USGS operates cooperatively with other agencies. The USGS and LCRA share data from stream discharge measurements and discharge ratings (stage vs. flow ratings). This collaboration improves the timeliness of updates to ratings for ongoing operations and provides an independent review of basic data on quantities of flow. USGS publishes final stream discharge estimates upon completion of its quality assurance/quality control processes. Because of the real-time nature of river operations, LCRA must necessarily rely on “provisional” data which is subject to change.

LCRA shares Hydromet data with the National Weather Service, West Gulf Coast River Forecast Center in Fort Worth, Texas (RFC). The RFC uses rainfall data from the Hydromet system to calibrate radar estimates of rainfall and to produce Quantitative Precipitation Estimates (QPE). The RFC then shares the QPE data with LCRA. This improves the hydro-meteorological information available to LCRA and the RFC, and allows each agency to more accurately predict lake levels and flow conditions along creeks and rivers in the Colorado River basin.

LCRA develops and maintains computer systems and protocols to collect data from its reservoirs and pump stations, and to communicate with major water users that operate reservoirs, pump stations, and wastewater treatment plants that contribute significant amounts of return flows to the Colorado River below Mansfield Dam. Data on expected and actual storage, diversions and return flows is used to plan water supply operations, to coordinate pumping operations and to report on water use.

### 5.3 DECISION SUPPORT MODELS

LCRA uses a number of specialized computer models to analyze the movement of water, help make decisions for river operations and allocate and report on water use.

#### 5.3.1 Water Supply Operations Models

LCRA has developed a suite of models for water supply operations including RiverWare models of the Colorado River and spreadsheet models for water supply operations.<sup>1</sup> Combined, these models make use of a variety of data sources described above, and are used to perform the following functions:

- Estimate the amount of flows entering the Colorado River;
- Evaluate the routing or timing and attenuation of flows released from the Highland Lakes to the lower Colorado River;
- Determine the necessary releases of stored water and pass-through of run-of-river flows to meet downstream demands;
- Schedule daily releases from dams; and
- Allocate releases and diversions for users to the appropriate source of supply (run-of-river or stored water) based on water rights priority.

#### 5.3.2 Flood Operations Model

LCRA has developed a Corps Water Management System (CWMS) model of the Colorado River basin for flood operations.<sup>2</sup> LCRA worked with the U.S. Army Corps of Engineers to

adapt CWMS software for real-time flood forecasting.

The CWMS model for flood operations uses rainfall, streamflow and lake level data to predict Highland Lake inflows and lake levels and to recommend flood releases according to flood control regulations and agreements. The CWMS model can use a variety of sources of rainfall data, including Hydromet rain gauge data and data from the RFC. Results from the flood operations model are used to evaluate alternative operational scenarios and to support final operational decisions.

#### 5.4 STANDARD GUIDELINES AND PROCEDURES FOR RIVER OPERATIONS

LCRA develops and maintains standard guidelines and procedures for three modes of River Operations: Water Supply Operations, Flood Operations and Alternative Operations. Water Supply Operations involve the release of water through a dam by means of hydroelectric turbines, and coordination of pumping by water supply customers to efficiently meet requirements for water supply, environmental flows, and hydroelectric generation. Alternative Operations, which is a variation of Water Supply Operations, involve the release of water through a dam by means of floodgates or spillways, for purposes of water supply. Flood Operations involve dam operations to mitigate damages due to uncontrolled inflows to the Highland Lakes. Each of these modes of operation is described below.

##### 5.4.1 Water Supply Operations

Water Supply Operations involve the scheduled release of water through hydroelectric generation for water supply, environmental and power production purposes, and for system storage adjustment.

During Water Supply Operations, water is captured and stored in lakes Buchanan and Travis up to the top of their conservation pool elevations, subject to available inflows. (Top of conservation pool for Lake Travis is elevation 681 feet msl and for Lake Buchanan it is 1020 feet msl; however, LCRA limits Lake Buchanan to 1018 feet in the months of May through October as discussed in Section 5.4.3.) The pass-through lakes (Inks, LBJ, Marble Falls and Austin) are normally maintained within a specified range of elevations at the dams shown in Table 5-1. Lake Austin is operated consistent with an agreement between LCRA and the City of Austin.<sup>3</sup> During flood operations, additional water may be temporarily stored in Lakes Buchanan and Travis and in the pass-through lakes.

**Table 5-1. Target Elevation Ranges for Pass-Through Lakes**

Lake Level at the Dam (Headwater Gauge)	Lower Elevation (Legacy Datum <sup>1</sup> )	Upper Elevation (Legacy Datum)	Adjustment to NAVD88
Inks	886.9	887.7	+0.31 ft.
LBJ	824.4	825.0	+0.68 ft.
Marble Falls	736.2	737.0	+0.69 ft.
Austin	491.8	492.8	+0.31 ft.

1. Elevations are based on the “legacy” datum for each dam. Legacy data are elevation benchmarks set for construction of the dams forming the Highland Lakes that have not been adjusted to a standard datum such as the National Geodetic Vertical Datum of 1929 (NGVD29) or the North American Vertical Datum of 1988 (NAVD88).

Within LCRA, Water Supply Operations involve a variety of key activities including:

- maintaining Hydromet field equipment and ratings to measure and reporting on rainfall, evaporation, streamflow, water levels and irrigation diversions;
- monitoring LCRA's water supply in the Colorado River and Highland Lakes on a daily basis; evaluating demands for water based upon specific orders and pumping status of certain customers, including the City of Austin, power plant customers and the irrigation operations, among others; determining the required releases of water from the Highland Lakes to most efficiently meet demands, consistent with water rights and agreements; and coordinating pumping operations of downstream customers;
- monitoring and reporting daily evaporation at lakes Travis and Buchanan; monitoring lake levels and river inflows on a 24/7 basis; determining availability of hydroelectric generating units; setting the final Hydro Schedule at each of the dams that form the Highland Lakes; and controlling hydroelectric generation operations; and
- coordinating hydroelectric generation with the Electric Reliability Council of Texas (ERCOT).

The following subsections describe the manner in which LCRA supplies demands and needs to be met or backed up with water from lakes Buchanan and Travis.

#### 5.4.1.1 Releases from Lake Travis

Miller Dam, which forms Lake Austin, is the dam downstream of Mansfield Dam, which forms Lake Travis. Lake Austin is the most downstream of the six Highland Lakes controlled by LCRA. The majority of LCRA's major irrigation and industrial customers divert water along the 300 river miles from Miller Dam to Matagorda Bay. Requirements for Instream Flows and Freshwater Inflows to Matagorda Bay apply along the Colorado River below Longhorn Dam (which forms Lady Bird Lake, immediately downstream of Lake Austin and is operated by the City of Austin). LCRA determines the daily release from Miller Dam to deliver water and regulate the flow in the lower river below Longhorn Dam. Releases from Mansfield Dam are determined as needed to maintain Lake Austin within its normal operating range.

Releases from Miller Dam require up to a week to flow along the river channel to reach the

points of delivery. Therefore, the timing of a release is as important as the quantity to ensure that the right amount of water is made available at the right place and the right time.

When making decisions regarding the daily operations of the Colorado River and Highland Lakes, LCRA first considers the location, amount and timing of the demands of major customers that take water from the Colorado River below Mansfield Dam and the environmental requirements for instream flows and freshwater inflows to Matagorda Bay. LCRA next considers the requirements of all water rights and agreements that apply to each demand and uses the best information available at the time to estimate the amount and timing of run-of-river inflows to the Colorado River below Mansfield Dam, and to the Highland Lakes above Mansfield Dam. Finally, LCRA determines the minimum amount of stored water that must be released from Mansfield Dam to meet any demands that do not have access to run-of-river sources of supply. Releases are then scheduled from Miller Dam and Mansfield Dam to meet all demands as efficiently as possible (i.e., with the least amount of stored water released from the Highland Lakes) and according to all applicable requirements.

For example, downstream demands that can be met from downstream run-of-river water rights are first supplied with run-of-river flows entering the Colorado River below Mansfield Dam. If this source is not sufficient to meet all such demands, then the remaining demands are supplied with run-of-river flows entering the Colorado River above Mansfield Dam. Finally, any remaining demands are met with stored water from the Highland Lakes.

Demands and releases from Miller Dam are determined on a daily basis, but travel time to the points of diversion or stream gauges varies and is not necessarily an exact number of days. For example, the travel time may be three and a half days, rather than exactly three or four days. Furthermore, water released from Miller Dam tends to attenuate as it moves downstream, so that one day's release at Miller Dam may arrive at a downstream location over several days. Therefore, in practice, releases from Miller Dam may be averaged over one or more days as needed to efficiently supply downstream demands.

Various factors affect the movement and delivery of water to locations below Miller Dam. The amounts of water actually released through hydroelectric generation typically do not match precisely the amounts scheduled for release. Releases from Miller Dam to the lower river pass through Lady Bird Lake and Longhorn Dam, which are controlled by the City of Austin. The operation of Longhorn Dam can change the timing and flow rate of water released by LCRA upstream. Many diversions from the Colorado River, and return flows to the river are not controlled by LCRA. The natural characteristics of the channel along the lower river are constantly changing. Furthermore, flow measurements at gauging stations on tributary creeks and along the main stem of the Colorado River have a generally accepted margin of error. All these factors affect LCRA's ability to forecast the exact rate, timing, attenuation and gain or loss of flows along the lower river.

#### 5.4.1.2 Releases from Lake Buchanan

LCRA's water supply needs are met from both lakes Buchanan and Travis. Thus, releases from Lake Buchanan are routed through the intervening lakes and Lake Travis to help meet the

demands of LCRA's customers and environmental flow needs. Releases also maintain lakes Inks, LBJ, and Marble Falls within their normal operating ranges and are used to meet LCRA customer demands from these lakes. Allocation guidelines provide guidance in the determination of the amount of Lake Travis releases that should be supplied from corresponding releases from Lake Buchanan.

#### 5.4.2 Alternative Operations

Alternative Operations is a variation on Water Supply Operations that generally involves the release of water through a dam by means of floodgates or spillways at a rate that does not exceed the discharge capacity of the turbines at the dam. At Inks and Miller dams, Alternative Operations involve the release of water through the dams at a rate that does not exceed the discharge capacity of turbines at Buchanan or Mansfield dams, respectively, and when releases from Buchanan and Mansfield dams are not due to Flood Operations. Alternative Operations do not trigger emergency flood notifications to the public. Alternative Operations are used when necessary to compensate for hydroelectric generation units that are out of service, to provide for maximum hydroelectric generation capability, or to allow floodgates to be exercised during routine maintenance activities. Alternative operations at any dam would include use of partial floodgate openings or spillways to release the equivalent of any loss in turbine capacity at that dam.

#### 5.4.3 Flood Operations

LCRA conducts Flood Operations at the six dams that form the Highland Lakes to mitigate downstream damages due to uncontrolled inflows to the lakes. Flood Operations take precedence over scheduled water supply and environmental release operations.

Lake Travis is the only one of the Highland Lakes with a dedicated flood pool. Except for lakes Buchanan and Travis, the reservoirs formed by the dams do not have the ability to capture and store large volumes of runoff. Releases from one reservoir are generally passed through the next downstream reservoir.

At Buchanan Dam, Flood Operations begin when the level of Lake Buchanan is forecast or observed to exceed its conservation pool elevation. At Inks, Wirtz and Starcke dams, Flood Operations begin when flows into Inks Lake, Lake LBJ or Lake Marble Falls respectively are forecast or observed to exceed the normal discharge capacity of turbines at either dam and require the use of floodgates or spillways to pass the flow.

Flood Operations at Buchanan, Inks, Wirtz, and Starcke dams are pursuant to an agreement between LCRA and the Federal Emergency Management Agency (FEMA) dated March 8, 1990. (See Appendix B-2.) Under this agreement, conservation storage in Lake Buchanan is limited to elevation 1018 feet (two feet below maximum conservation storage) in the more flood-prone months of May through October.

At Mansfield Dam, Flood Operations begin when the level of Lake Travis is forecast or observed to exceed its conservation pool elevation. At Miller Dam, Flood Operations begin when releases exceed the discharge capacity of its two turbines.

Flood Operations at Mansfield Dam and Lake Travis are governed by U.S. Army Corps of Engineers (USACE) regulations and require LCRA to consult with USACE in their implementation. (See Appendix B-1.)<sup>4</sup> The current rules also provide that the U.S. Bureau of Reclamation will schedule flood releases as required for the safety of the dam when the reservoir level is forecast to exceed 722 feet msl. Operations at Miller Dam are governed by an agreement between LCRA and the City of Austin.<sup>5</sup>

Under the rules, the plan of operations for the release from Mansfield Dam is determined by: specified ranges of observed or forecasted reservoir levels; the pool condition (i.e., rising or falling); the month of year; and stage and flow criteria at three designated downstream locations. When the pool is rising, forecasted reservoir levels (based on actual water on the ground) are used in determining flood release requirements. When the pool is falling, observed reservoir levels are used in determining release requirements. The amount of the release from Mansfield Dam increases with higher ranges of reservoir level as long as downstream stage and flow limitations are not exceeded.

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1. RiverWare is a modeling environment developed by the Center for Advanced Decision Support for Water and Environmental Systems (CADSWES) at the University of Colorado.
  2. CWMS is a software program developed by the U.S. Army Corps of Engineers.
  3. Lease and Agreement between City of Austin and Lower Colorado River Authority, February 5, 1938
  4. Guidance in the implementation of these rules may be obtained from the USACE Marshall Ford (Mansfield) Dam Water Control Manual (1999) and Bureau of Reclamation Marshall Ford (Mansfield) Dam Standing Operating Procedures (1993).
  5. See endnote 3.

**TECHNICAL PAPER A-1**  
**DEVELOPMENT OF PROJECTED FIRM DEMANDS**  
**January 2012**

One of the key assumptions in developing a new update to LCRA's Water Management Plan (WMP) is the projected water demands. LCRA supplies water to two general categories of water demands: firm and interruptible. LCRA's WMP approved in 2010 was formulated based on projections of firm and interruptible demands for the 2010 timeframe. For this revision to LCRA's WMP, future demand assumptions were forecast through year 2020. The Water Management Plan Revision Advisory Committee (Committee) reached consensus on LCRA developing an interim level of firm demands about halfway between 2010 and the 2020. A mechanism for transitioning from the interim procedures to the future 2020 procedures was developed but is not the subject of this document.

A fundamental assumption of this WMP update process was to use the same future projected demands as in LCRA's Water Supply Resource Plan (WSRP)<sup>1</sup>. Firm demands in the WSRP include existing and projected future firm demands for municipal, industrial, steam electric, agricultural, recreation, domestic, and other uses within LCRA's service area. It also includes demands where LCRA backs up other water right holders' rights, i.e. City of Austin, South Texas Project Nuclear Operating Company (STPNOC) and Bastrop Energy Partners. Development of these projected firm demands for the WSRP leveraged prior work by the Texas Water Development Board and the Lower Colorado Regional Water Planning Group (Region K)<sup>2</sup> but updated the demands where appropriate based on more recent growth trends and discussions with local entities.

Furthermore, the projected firm water demands were based on the approved 2006 Region K plan demands but included a county by county re-examination with generally higher projections, where appropriate, based on population and industrial trends. Some specifics of the approach include:

- a) Municipal demands developed using substantiated revised population estimates based on recent growth patterns to estimate growth through 2040;
- b) Municipal demands for each decade were calculated based on population projections using the same per capita water use approach used in 2006 Region K plan which includes a decline in per capita water use into the future;
- c) New and pending contracts for municipal demand;
- d) Projected domestic use on the Highland Lakes;
- e) Region K industrial demand, and new and pending contracts for industrial use;
- f) Conveyance losses from the point of release of water from the Highland Lakes to the point of delivery for existing contracts; and
- g) Other unanticipated releases from the reservoirs (such as emergency hydro).

While firm demands for the 2010 WSRP were projected into the future to year 2100, only the 2020 demand projections were used in the WMP update process. These projections, which incorporated population projections from numerous sources that were cross checked with local, state, and federal population estimates, were utilized by the Region K Water Planning

Group in the development of its most recent regional water plan. The 2020 demands used in the WMP are summarized in the Table 1. Projected year 2030 firm demands are shown in Table 1 for reference purposes only.

**Table 1 – WMP Annual Firm System Demand Projections**

	WMP	WMP Future Projections *		
	2010	Interim	2020	2030
<b>Firm Demands (in acre-feet per year)</b>				
City of Austin Municipal <sup>1</sup>	182,788	193,334	203,880	232,923
LCRA Power Plants	25,866	25,866	25,866	25,866
City of Austin Power Plants <sup>2</sup>	13,500	20,851	28,202	31,502
Other Municipal & Industrial <sup>3</sup>	46,452	92,252	138,052	183,843
Other (conveyance & emergency)	20,000	20,000	20,000	20,000
<b>Total</b>	<b>288,606</b>	<b>352,303</b>	<b>416,000</b>	<b>494,134</b>
STPNOC Firm Backup <sup>4</sup>	20,000	20,000	40,000	40,000
<b>Other Major Run of River Diverters</b>				
Garwood - Corpus Christi	-	-	35,000	35,000
STPNOC/LCRA	102,000	102,000	102,000	102,000
Notes:				
Notes:				
1. Future projections of water demands based on LCRA Water Supply Resource Plan & Region K.				
2. These customers contractually depend on run-of-river water rights with back-up (firm) water supplies from LCRA. The projected numbers reflect the total of the run-of-river water rights and the amount of contracted back-up water supplies needed from LCRA.				
3. Municipal includes other firm demands such as recreation and irrigation. Also included is domestic use around the Highland Lakes.				
4. STPNOC total diversions under run of river and firm back-up are limited to 102,000 acre-feet through year 2030.				

The demands shown in Table 1 were further disaggregated for modeling purposes to represent their geographic location in the river system and their priority (for water rights that LCRA provides back-up water supplies), if applicable. Also, delivery factors are assigned to some of the downstream demands as shown in Table 2. These factors represent the percentage of additional releases of stored water from the lakes Buchanan and Travis to account for losses during delivery to the downstream diversion point(s).



**Table 2 –Downstream Delivery Loss Factors**

Diverter	Delivery Factor
Fayette Power Plant	6.5%
Gulf Coast Industrial	10.9%
STPNOC	11.5%

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<sup>1</sup> LCRA Water Supply Resource Plan, October 2010 located at - [http://www.lcra.org/library/media/public/docs/water/wsrp/wsrp\\_final\\_pppdiscussion\\_10132010.pdf](http://www.lcra.org/library/media/public/docs/water/wsrp/wsrp_final_pppdiscussion_10132010.pdf).

<sup>2</sup> Texas Water Development Board and Lower Colorado Regional Planning Group, 2001 Adopted Regional Plan, December 2001 located at- [http://www.twdb.state.tx.us/RWPG/2001\\_RWP/k/Submitted\\_Files/](http://www.twdb.state.tx.us/RWPG/2001_RWP/k/Submitted_Files/) and Texas Water Development Board and Lower Colorado Regional Planning Group, 2006 Adopted Regional Plan, January 2006 located at - [http://www.twdb.state.tx.us/rwpg/2006\\_RWP/RegionK/](http://www.twdb.state.tx.us/rwpg/2006_RWP/RegionK/)

**TECHNICAL PAPER A-2**  
**DEVELOPMENT OF PROJECTED AGRICULTURAL DEMANDS BY THE**  
**FOUR DOWNSTREAM IRRIGATION OPERATIONS**  
**January 2012**

For this revision to LCRA's Water Management Plan (WMP), future agricultural demand assumptions were needed. The Water Management Plan Revision Advisory Committee (Committee) indicated that they only wanted LCRA to develop a plan based on firm demands through year 2020. The Committee also wanted an interim step in firm demands before the full 2020 firm demands might be realized. A mechanism for transitioning from the interim operations to the future 2020 operations was developed but is not the subject of this document.

A fundamental assumption of the WMP process was to use the same future agricultural demands as in LCRA's Water Supply Resource Plan (WSRP) and the LCRA Water Supply Strategies for Agriculture. The WSRP leveraged prior work by the Texas Water Development Board and the Lower Colorado Regional Planning Group (Region K).

Drought demands were taken from the WSRP which was based on the Lower Colorado Regional Planning Group Adopted Plan (TWDB 2006). These projected demands for 2010 agreed reasonably well with the actual observed diversions for the drought years of 2008 and 2009 as shown in Table 1, with the exception of the Gulf Coast operation.

**Table 1. Actual Diversions by Irrigation Operation\***

<b>Year</b>	<b>Irrigation Operation</b>				
	<b>Garwood (ac-ft)</b>	<b>Lakeside (ac-ft)</b>	<b>Gulf Coast (ac-ft)</b>	<b>Pierce Ranch (ac-ft)</b>	<b>Total (ac-ft)</b>
2008	103,600	134,300	160,000	22,700	420,600
2009	101,800	115,900	197,100	27,800	442,600
2010	82,100	101,300	145,400	22,400	351,200
* inclusive of March through October for comparative purposes					

Agricultural diversions by the four major downstream operations are forecast in the approved Region K Water Plans to decrease over time as a continuation of a long term trend. The stated reasoning from the source documents for the decrease is improved water use efficiency and decreasing economic outlook (TWDB 2001 and 2006). These demand projections are shown in Table 2. A change was made to the 2010 baseline from the projected diversions for the Gulf Coast irrigation operation because Gulf Coast's projected 2010 diversion of 123,000 ac-ft was lower than the actual average diversion for 2008 and 2009 of 178,700 ac-ft. Therefore, the average for 2008 and 2009, which were

both drought years, was substituted for the projected Gulf Coast diversions in 2010. Final 2010 diversions were not available at the time of this original analysis but are presented here for completeness. This substitution would not impact actual diversions in 2020 and beyond but would necessitate a declining water use to be consistent with the forecasted diversion reductions. A similar reduction in diversions was forecast in the 2010 Water Management Plan (LCRA & TCEQ, 2010).

**Table 2. Projected 90th Percentile Diversions by Irrigation Operation**

Year	Irrigation Operation				
	Garwood (ac-ft)	Lakeside (ac-ft)	Gulf Coast (ac-ft)	Pierce Ranch (ac-ft)	Total (ac-ft)
2010	92,400	139,700	178,700*	27,700	438,500
2020	89,700	135,500	147,400*	27,000	399,600
2030	87,100	131,300	116,100	26,200	360,700
2040	85,300	128,100	113,400	25,600	352,400
2050	83,600	124,900	110,700	24,900	344,100
2060	81,400	122,100	107,300	24,500	335,300
Notes: *Adjusted upward from WSRP and TWDB projections to the 2008 and 2009 average use. 90 <sup>th</sup> Percentile – means that the values are at or below the projected diversions in 90% of the years.					

In actual operations, agriculture diversions can vary widely with weather conditions even for similar acreage. This can be seen in the variability in Table 1 from the drought years of 2008 to 2009 to the more normal first crop season of 2010. This weather variability has been considered in each of the previous revisions to the WMP. Weather variability is captured with good agreement using statistical relationships which have been updated from time to time as newer and more data becomes available but have remained fundamentally similar (LCRA, 2010). The regression equations capture the variability of agricultural demands by crop based on acreage cultivated, precipitation, and evaporation. Using the regression equations, weather varied demands were developed for the WAM period of simulation (1940 to 2009) which conforms to the actual diversions shown in Table 1. These weather varied agricultural demands were then used in the WMP WAM simulations. The 2010 demands were used for 2010 baseline and interim curtailment evaluations, and the 2020 demands were used in the 2020 curtailment evaluations.

A unique aspect of agricultural water use in the lower Colorado River basin is that agricultural diversions are not necessarily the same as agricultural demands on the system. This is due to a five to seven day advance order requirement to provide water supplies in a reliable manner. To more accurately simulate releases to meet the downstream diversions, factors were calculated as the average of actual orders and diversions for irrigation seasons of 2001 to 2010. The resulting monthly average values by irrigation operation are shown in Table 3.

**Table 3. Orders over Diversion Factors used in WAM**

Month	Average Factor by Irrigation Operation			
	Garwood	Lakeside	Pierce	Gulf Coast
March	1.20	3.63	1.38	1.17
April	2.06	3.42	1.91	1.53
May	1.28	1.23	1.32	1.06
June	1.26	1.38	1.38	1.11
July	1.75	1.93	2.60	1.39
Aug	1.24	1.46	1.32	1.10
Sept	1.43	1.88	1.71	1.33
October	1.62	1.78	2.39	1.18
Annual	1.35	1.46	1.75	1.23

Table 4 represents the inverse of the Table 3 factors – the percentage of water ordered that is diverted on average, which could be considered the diversion efficiency.

**Table 4. Average Diversion Efficiency 2001-2010**

Month	Garwood	Lakeside	Pierce	Gulf Coast
March	84%	28%	73%	85%
April	49%	29%	52%	65%
May	78%	82%	76%	95%
June	79%	72%	72%	90%
July	57%	52%	39%	72%
Aug	81%	68%	76%	91%
Sept	70%	53%	59%	75%
October	62%	56%	42%	85%
Annual	74%	69%	57%	81%

Undiverted orders become a potential source of water for downstream users such as the South Texas Nuclear Operating Company, environmental instream flows, and environmental flows to Matagorda Bay. It may be noted from this information that Gulf Coast is the most efficient at diverting its orders, which is likely due to the advantage of the Lane City and Bay City Dams to store releases from the Highland Lakes. Similarly Garwood also has a small pumping pool and is nearly as efficient. Neither Lakeside nor Pierce Ranch have pumping pools on the river which likely influences the lower efficiencies.

## References

Parsons, [Future Irrigation Water Diversions, 2010-2090](#), Final Report Prepared for LCRA and SAWS, September 1, 2006.

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**TECHNICAL PAPER A-3**  
**ASSUMPTIONS UNDERLYING LCRA 2010 WATER MANAGEMENT PLAN**  
**BASELINE WATER AVAILABILITY MODEL**  
**January 2012**

Basic assumptions included in the baseline water availability models (WAM) that are being used to support the development of the revised Water Management Plan (WMP) for the Lower Colorado River basin are summarized below. Fundamental to the structure of these baseline WAMs, as currently coded, is that they all incorporate the provisions of the 2010 WMP relating to curtailment of interruptible water and environmental flow criteria. Baseline WAMs have been developed to represent future demands conditions for LCRA's water supply customers and reservoir storage conditions corresponding to the years 2010, 2020, and 2030.

**1. GENERAL**

- 1.1. The TCEQ's water availability model of the Colorado River basin (Run 3) forms the basic structure for the LCRA baseline WAMs, and this model is assumed to appropriately reflect water rights and hydrologic conditions in the basin to provide for meaningful and accurate simulations of water availability. The Texas A&M University "Water Rights Analysis Package" (WRAP) is the program code used for all WAM simulations.
- 1.2. For purposes of supporting the development of an updated WMP, the TCEQ's WAM has been adapted to better represent an operational model of LCRA's water supply system, including the incorporation of specific operating rules for lakes Buchanan and Travis and for providing water to LCRA's water supply customers.
- 1.3. The LCRA baseline WAMs include the "no-call" assumption with regard to all water rights located upstream of the Highland Lakes ("cutoff model").<sup>1</sup> This assumption, in effect, makes all water rights upstream of the Highland Lakes senior in priority to the Highland Lakes and other downstream water rights.
- 1.4. The 1940-1998 monthly naturalized flows and net evaporation rates incorporated into the TCEQ's Run 3 WAM for the Colorado River basin have been extended<sup>2</sup> through calendar year 2009, and this extended database is used in the LCRA baseline WAMs for the simulation period. These data are assumed to be representative of actual variations in hydrologic conditions sufficient to support meaningful and accurate simulations of water availability, including the 1950s drought of record.
- 1.5. Water demands for all surface water users in the Colorado River basin that are not partially or wholly supplied by LCRA's water delivery system (the Highland Lakes and LCRA's lower basin water rights) are conservatively assumed to be equal to the

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<sup>1</sup> The "no-call" assumption in the WAM is an attempt to reflect (in a modeling tool) the various agreements that LCRA has with upstream reservoir owners, i.e. Colorado River Municipal Water District, San Angelo Water Supply Corporation, and Brown County WID No. 1, and to better represent actual conditions with regard to the operation of existing water rights throughout the basin.

<sup>2</sup> The naturalized flows for the 1999-2009 period were developed by LCRA using the same methodology applied in developing the original WAM for the Colorado River Basin.

maximum annual diversion amounts authorized by their individual water rights as reflected in TCEQ's Run 3 WAM.

## 2. LOWER BASIN RELIABLE RUN-OF-RIVER SUPPLIES

- 2.1. In the baseline WAMs, to more accurately reflect the actual quantity of releases (inflow pass-throughs and stored water) from the Highland Lakes needed to meet LCRA's downstream irrigation demands and to supply certain other customers in a manner consistent with historical operations, the supply of run-of-river water originating downstream of Mansfield Dam that is assumed available for diversion by these water users is limited to quantities that historically have proven to be reliable considering base flows in the lower segments of the Colorado River that are sustained with groundwater inflows and the return flows discharged from the City of Austin's wastewater treatment plants.<sup>3</sup>
- 2.2. The base flow portions of these downstream reliable river flows have been determined by LCRA staff for specific reaches of the river, and these quantities are stipulated in the baseline WAMs as follows:

Mansfield Dam to Austin gage	2,600 ac-ft/month
Austin gage to Bastrop gage	0 ac-ft/month
Bastrop gage to Columbus gage	3,900 ac-ft/month
Columbus gage to Wharton gage	3,133 ac-ft/month
Wharton gage to Bay City gage	1,567 ac-ft/month

Hence, with regard to flows originating downstream of Mansfield Dam, there is a maximum of only 11,200 acre-feet of base flows plus Austin's return flows in any given month that are assumed to be reliably available for supplying LCRA's downstream irrigation demands and certain water supply customers.

- 2.3. In addition to LCRA's irrigation demands at the four downstream irrigation operations, the run-of-river demands of Austin at the Fayette Power Plant and the City of Corpus Christi's Garwood water right also are subject to the availability of the reliable downstream river flows.
- 2.4. Prior to any diversions being made, the total quantity of reliable downstream river flow at any location along the lower Colorado River is equal to the sum of Austin's return flows and the sum of the incremental reliable river flows that originate in each of the upstream reaches of the river.
- 2.5. The total quantity of reliable downstream river flow at any location along the lower Colorado River is reduced as diversions are made upstream in priority order by the individual irrigation operations, Austin at Fayette Power Plant, and the City of Corpus Christi's Garwood water right at their respective diversion points.

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<sup>3</sup> This limitation on available flows in the lower Colorado River is considered to be appropriate based on LCRA's historical operational experience attempting to provide inflows and stored water from the Highland Lakes to downstream water users on a daily basis while also taking into consideration the actual river flows in the lower basin that can be effectively diverted on a daily basis by the lower basin water users.

### **3. MUNICIPAL, INDUSTRIAL, POWER GENERATION, AND OTHER FIRM DEMANDS**

- 3.1. For 2010, municipal, industrial, power generation and other firm water demands partially or wholly supplied by LCRA's water are based primarily on the existing 2010 projected demands included in the 2010 WMP, which are similar to the actual water used by these water users during calendar years 2008 and 2009. Adjustments that have been made to these 2010 WMP demands for purposes of the current 2010 baseline WAM include the following:
- 3.1.1. A firm demand of 5,000 ac-ft/year for domestic water use has been included as a direct diversion from the Highland Lakes. This demand has been separated out from the other demands. To date, LCRA has issued a significant number of firm water contracts for domestic use. Although LCRA has not issued contracts for all of this water, and most, if not all diverters from the Highland Lakes do not have a legal right to divert absent a contract, LCRA recognizes that this demand exists, and that the number of contracts for domestic use has increased. Thus, LCRA has included the full amount of estimated domestic use in model simulations.
  - 3.1.2. Based on input from City of Austin staff, in addition to Austin's municipal demand that is met from the Colorado River (182,788 ac-ft/year), an irrigation demand amount equal to 5,143 ac-ft/year also has been included for Austin, which is satisfied entirely through direct reuse of Austin's treated wastewater effluent.
  - 3.1.3. Based on input from City of Austin staff, an additional demand of 2,315 ac-ft/year for Austin Energy's Sand Hill power plant has been added, with all of this demand supplied through direct reuse of Austin's treated wastewater effluent.
  - 3.1.4. Based on input from City of Austin staff, the demand for Austin Energy's Decker power plant has been set at 5,000 ac-ft/year, with this demand satisfied with Austin's Decker water right first, then backed up with LCRA's Highland Lakes water, as necessary, consistent with the 1999 Agreement.
  - 3.1.5. Based on input from City of Austin staff, the demand for Austin Energy at Fayette Power Plant has been set at 8,500 ac-ft/year, with this demand first satisfied with Austin's Lady Bird Lake water right (Certificate of Adjudication 14-5471, as amended) (subject to available reliable downstream river flows as per §2.2 above), then backed up with LCRA's Highland Lakes water, as necessary, consistent with LCRA's separate contract with Austin for FPP.
- 3.2. For 2020 and 2030, future municipal, industrial, power generation and other firm water demands partially or wholly supplied by LCRA's water are based on projections of anticipated population growth and increases in manufacturing, industrial and electrical generation water needs developed by LCRA staff pursuant to the development of the LCRA Water Resource Supply Plan and additional input from City of Austin staff:
- 3.2.1. In addition to Austin's projected M&I demands that are met from the Colorado River (203,880 ac-ft/year in 2020 and 232,923 ac-ft/year in 2030), irrigation



demand amounts equal to 13,620 ac-ft/year in 2020 and 22,077 ac-ft/year in 2030 also have been included for Austin which are satisfied entirely through direct reuse of Austin's treated wastewater effluent.

- 3.2.2. Demands for Austin Energy's Sand Hill power plant have been set as follows, with these demands satisfied from the indicated sources (with no backup using LCRA's lakes Buchanan and Travis water):

<u>Source of Supply</u>	<u>2020 ac-ft/yr</u>	<u>2030 ac-ft/yr</u>
Direct Reuse of Austin's WW Effluent	3,315	7,315
Austin's Town Lake Water Right	<u>1,685</u>	<u>1,685</u>
Total Demand	5,000	9,000

- 3.2.3. Demands for Austin's Decker power plant have been projected at 13,500 ac-ft/year for both 2020 and 2030, with these demands satisfied first using Austin's Decker water right (Certificate of Adjudication 14-5489, as amended), then backed up with LCRA's Highland Lakes water, as necessary, consistent with the 1999 Agreement.
- 3.2.4. Demands for Austin at Fayette Power Plant are projected at 14,702 ac-ft/year for 2020 and 18,002 ac-ft/year for 2030, with these demands satisfied first using Austin's Town Lake water right (subject to available reliable downstream river flows as per §2.2 above), then backed up with LCRA's Highland Lakes water as necessary, consistent with LCRA's separate contract with Austin for FPP.
- 3.2.5. Austin's Town Lake water right (subject to available reliable downstream river flows as per §2.2 above) is used first to satisfy demands for Austin at Fayette Power Plant and then the demands for Austin's Sand Hill power plant, with the sum of these diversions limited to 24,000 ac-ft/year.
- 3.3. For 2010, 2020 and 2030, an additional firm demand of 20,000 ac-ft/year on the Highland Lakes is included in the baseline WAMs as releases from the Highland Lakes to represent the adjustments to releases associated with hydropower scheduling and other emergency releases from Lake Travis.
- 3.4. In the 2010, 2020 and 2030 baseline WAMs, all of the municipal, industrial, power generation and other firm water demands that are provided water from LCRA's water delivery system are satisfied either entirely with stored water directly from the Highland Lakes or with run-of-river diversions backed up with stored water from the Highland Lakes. The City of Austin's water demands for M&I uses and power generation and the South Texas Project are the major LCRA-associated demands, other than irrigation, that are supplied with run-of-the-river water from the Colorado River to the extent it is available.<sup>4</sup>

<sup>4</sup> Other firm water contract customers who own and use their run-of-river water rights in conjunction with water supplies purchased from LCRA include Bastrop Energy Partners, Meadowlakes, and Kingsland WSC.

- 3.5. In the 2010, 2020 and 2030 baseline WAMs, with the exception of the Sand Hill run-of-river demand as noted above, all of the municipal, industrial power generation and other firm water demands supplied by LCRA's water are fully satisfied (firm).

#### 4. CITY OF AUSTIN RETURN FLOWS

- 4.1. For 2010, 2020 and 2030 conditions, return flows discharged from the City of Austin wastewater treatment plants into the Colorado River are determined using procedures consistent with those employed by the Region K Water Planning Group involving the following calculations:

- At the end of each monthly time step during a WAM simulation, the total amount of Colorado River diversions made by the City of Austin to satisfy its M&I water demands is noted.
- The total quantity of treated wastewater effluent associated with Austin's total M&I river diversions then is calculated by applying the corresponding monthly factor from the following list to Austin's total amount of M&I river diversions. These factors were derived based on Austin's actual river diversions and return flows reported for the 2000-2005 period.

Jan	Feb	Mar	Apr	May	Jun
0.7873	0.8027	0.7994	0.6487	0.5509	0.5379
Jul	Aug	Sep	Oct	Nov	Dec
0.4597	0.4213	0.4821	0.5806	0.7215	0.7735

- At the beginning of the following time step, the calculated amount of Austin's treated wastewater effluent from the previous time step is reduced by the amount of Austin's demand that is expected to be satisfied by direct reuse for irrigation and for the Sand Hill power plant.
  - The remaining quantity represents the total amount of return flows that is discharged to the Colorado River at the beginning of the current time step.
- 4.2. For 2010, 2020 and 2030 conditions, no indirect reuse of Austin's return flows is included in the baseline WAMs because the City of Austin has not identified any indirect reuse projects in the 2011 Region K Plan through at least the year 2060; consequently, all of Austin's return flows, save and except those identified above as being directly reused, are discharged to the river and are available for use by all downstream water users in accordance with the prior appropriation doctrine and consistent with the 2007 Settlement Agreement.

#### 5. LCRA IRRIGATION DEMANDS

- 5.1. Water demands associated with the four downstream irrigation operations (Garwood, Lakeside, Pierce Ranch and Gulf Coast) for 2010, 2020 and 2030 have been projected by LCRA staff taking into consideration the Region K projections, with adjustments derived from actual historical data for the past 20 years to incorporate historical climatic variations in the demands on an annual basis. First and second crop acreages (uncurtailed planted acreage) have been adjusted to maintain the historical split from

2006 to 2010 for each irrigation operation. The percentages of second crop acres to first crop acres for Garwood, Lakeside, Pierce Ranch, and Gulf Coast for this period were 82%, 58%, 74% and 63% respectively. A generalized pattern of monthly use for irrigation has been applied to the annual demand quantities to derive monthly demand estimates for each year of the 1940-2009 simulation period used in the baseline WAMs.

- 5.2. Water demands associated with the four downstream irrigation operations are satisfied with available run-of-river supplies originating downstream of Mansfield Dam first, then with available inflows passed through the Highland Lakes, and finally, in many cases, with interruptible stored water from lakes Buchanan and Travis.
- 5.3. In the baseline WAMs, the supply of run-of-river water originating downstream of Mansfield Dam that is assumed to be available for diversion by the downstream irrigation operations is limited to the available supply of reliable river flows as described in Section 2 above.
- 5.4. Lakes Buchanan and Travis water supplies for LCRA's irrigation operations in the lower basin are subject to curtailment in accordance with provisions in the 2010 WMP, with the degree of curtailment dependent upon the quantity of water stored in lakes Buchanan and Travis on January 1<sup>st</sup> of each year. In the baseline WAMs, once the degree of curtailment is determined, corresponding but separate curtailment factors are applied to reduce the monthly demand values for the second and first crops, respectively, in order to achieve the appropriate level of curtailment.
- 5.5. When the combined storage in lakes Buchanan and Travis is above 325,000 ac-ft on January 1<sup>st</sup> of any year or 200,000 ac-ft at any time, the available supply of lakes Buchanan and Travis water for the Garwood irrigation operation (and its demands) is assumed to not be curtailed. This conservative assumption is based upon the historically high reliability of the Garwood water right and corresponding low demand for backup water under historic hydrologic conditions. However, the Garwood irrigation operation could face a curtailment under future hydrologic conditions such as a recurrence of the extreme dry conditions from year 2011 even if combined storage is above the 325,000 and 200,000 acre-foot values. As this technical paper was being finalized there exists a significant chance of such a curtailment in 2012. If the combined storage in the reservoirs falls below 325,000 ac-ft on January 1<sup>st</sup> of any year or 200,000 ac-ft at any time, then the available supply to Garwood from above Mansfield Dam is limited to only the inflows into the Highland Lakes to which the Garwood water right is entitled.
- 5.6. For the non-Garwood irrigation operations (Lakeside, Pierce Ranch and Gulf Coast), the available supply of Highland Lakes water for the second crop is not curtailed as long as the combined storage in Lakes Buchanan and Travis on January 1<sup>st</sup> of any year is above 1.4 million acre-feet. Curtailment of the second crop supply (actually reduction of the second crop demands in the WAMs) is assumed to begin as the combined storage in the reservoirs falls below 1.4 million acre-feet and increases stepwise from a zero curtailment factor at 1.4 million acre-feet up to a curtailment factor of 81.2% at 725,000 ac-ft of system storage. Below 725,000 ac-ft of combined storage on January 1<sup>st</sup>, no water is provided for the second crop (the second crop demands are set equal to zero). The available supply of lakes Buchanan and Travis water for the first crop for the non-Garwood irrigation operations (the first crop

demands in the WAMs) is assumed to not be curtailed as long as the combined storage in lakes Buchanan and Travis on January 1<sup>st</sup> of any year is above 325,000 ac-ft. When the combined storage in lakes Buchanan and Travis on January 1<sup>st</sup> of any year falls below 325,000 ac-ft, providing irrigation water supplies for the Lakeside and Gulf Coast irrigation operations and Pierce Ranch is ceased, and in the baseline models their demands are set equal to zero.

- 5.7. When the combined storage in lakes Buchanan and Travis at any time falls below 200,000 ac-ft, no lakes Buchanan and Travis water is made available for satisfying the demands of the non-Garwood irrigation operations, i.e., Lakeside, Gulf Coast and Pierce Ranch.
- 5.8. For any year when curtailment of lakes Buchanan and Travis water supplies is declared for the irrigation operations because the combined storage in lakes Buchanan and Travis is less than 1.4 million acre-feet on January 1<sup>st</sup>, if the combined storage in lakes Buchanan and Travis subsequently rises above the curtailment trigger of 1.4 million acre-feet prior to March 1<sup>st</sup>, then the curtailment is lifted and full irrigation water supplies are provided to satisfy all first and second crop demands for the entire year.
- 5.9. In any year when the lakes Buchanan and Travis water supplies for the downstream irrigation operations are curtailed, if the combined storage in lakes Buchanan and Travis subsequently rises above the curtailment trigger of 1.4 million acre-feet during the period from March 1<sup>st</sup> through July 31<sup>st</sup>, then the curtailment of the second crop demands is adjusted as of August 1<sup>st</sup> to be equal to the first crop curtailment (same curtailment factor).
- 5.10. Return flows to the Colorado River from the downstream irrigation operations are discharged each month of the simulation period after all irrigation diversion activities have been completed, with these return flows calculated based on the following percentages of the total water supply utilized by each of the irrigation operations during that month:

Garwood	3 %	Lakeside	2 %
Pierce Ranch	18 %	Gulf Coast	10 %

## **6. HIGHLAND LAKES STORAGE AND RELEASES**

- 6.1. Based on recent sedimentation studies conducted by the Texas Water Development Board (TWDB) and extrapolation of these data by LCRA to the year 2030, the combined conservation storage capacity of lakes Buchanan and Travis is projected to continue to decrease due to sedimentation from 2,008,028 acre-feet in 2010 to approximately 1,992,947 acre-feet in 2030.
- 6.2. The conservation storage capacity of Lake Buchanan at elevation 1020 feet msl is expected to decrease from approximately 873,572 acre-feet in 2010 down to approximately 863,491 acre-feet in 2030.
- 6.3. The conservation storage capacity of Lake Travis at elevation 681 feet msl is projected to decrease from approximately 1,134,456 acre-feet in 2010 down to approximately 1,129,456 acre-feet in 2030.

- 6.4. To reflect expected future operating procedures due to on-going a dam modification project, the top of the conservation pool for Lake Buchanan is set at a constant of 1018 feet msl in the 2010 and 2020 baseline WAMs, and it is varied between 1018 feet msl for May through October and 1020 feet msl for November through April in the 2030 baseline WAM.
- 6.5. To be consistent with current LCRA operations and accounting procedures, the quantity referred to as “storable inflows” to lakes Buchanan and Travis is determined in the WMP baseline WAMs as the volume of available inflows that is capable of being stored in the reservoirs at the 1926 priority date immediately after inflows to the reservoirs have been passed downstream to satisfy the demands associated with LCRA’s senior run-of-river water rights, Austin’s Fayette power plant demand, City of Austin, Bastrop Energy, the Corpus Christi Garwood demand, and other demands. The storable inflows quantity is the amount of inflows that is made available to satisfy environmental flow needs, except that stored water also is made available for satisfying critical instream flow needs, if necessary.
- 6.6. Requirements for releases from lakes Buchanan and Travis to satisfy the demands of LCRA’s downstream M&I water users below La Grange are increased by the following factors to account for delivery losses along the lower Colorado River, and once such carrying water passes the associated points of diversion, it is available for diversion and use by all downstream users, with the exception of those demands whose run-of-the-river supplies are limited to the reliable downstream river flows as described in Section 2 above, i.e., the downstream irrigation operations, Austin’s Fayette power plant demand, and the Corpus Christi Garwood demand.

<u>Diverter</u>	<u>Delivery Factor</u>
Fayette Power Plant	6.5 %
Matagorda County Industrial/Power Generation	10.9 %
South Texas Project	11.5 %

- 6.7. Requirements for releases from lakes Buchanan and Travis to satisfy the demands of the downstream irrigation operations (to the extent there are demands for a particular month) are increased by the following monthly delivery factors to account for delivery losses along the lower Colorado River and for water that was ordered to meet requested demands but was not diverted due to weather or other circumstances. Once such ordered water passes the associated points of diversion, it is available for diversion and use by all downstream water rights, with the exception of those demands whose run-of-the-river supplies are limited to the reliable downstream river flows as described in Section 2 above, i.e., the downstream irrigation operations, Austin’s Fayette power plant demand, and the Corpus Christi Garwood demand.

Month	Garwood	Gulf Coast	Lakeside	Pierce Ranch
January	n/a	n/a	n/a	n/a
February	n/a	n/a	n/a	n/a
March	20 %	17 %	263 %	38 %
April	106 %	53 %	242 %	91 %
May	28 %	6 %	23 %	32 %
June	26 %	11 %	38 %	38 %
July	75 %	39 %	93 %	160 %
August	24 %	10 %	46 %	32 %
September	43 %	33 %	88 %	71 %
October	62 %	18 %	78 %	139 %
November	n/a	n/a	n/a	23 %
December	n/a	n/a	n/a	n/a

- 6.8. Releases from lakes Buchanan and Travis that are made to reflect the adjustment to releases associated with hydropower scheduling and other emergency releases are available only for diversion by the South Texas Project under its run-of-river water right, and they are not accounted for in downstream river flows when determining the required releases from lakes Buchanan and Travis for satisfying instream flow requirements.
- 6.9. Releases of stored water from Lake Buchanan are made to maintain the intervening Highland Lakes (Lake Inks, Lake LBJ, and Lake Marble Falls) full within an established operating range. In addition, releases of stored water from Lake Travis are made to maintain Lake Austin and Lady Bird Lake within an established operating range.
- 6.10. Procedures in the WAMs for making releases from either Lake Buchanan or Lake Travis to meet downstream water demands use the reservoir system operating rules that are embedded in the basic WRAP program. At any time, the relative storage conditions of the two reservoirs determine from which reservoir releases are to be made, with the overall objective of using water from Lake Travis at a somewhat higher rate than from Lake Buchanan in order to minimize flood spills from Lake Travis when Lake Buchanan is not full and to ensure that water stored in Lake Travis is fully utilized before the last release is made from Lake Buchanan when and if the reservoir system becomes fully depleted. Procedures for making releases under the current reservoir operating rules in the WAMs for Lakes Buchanan and Travis in the WAMs are as follows:
- (1) An Upper Zone (Zone 1) and a Lower Zone (Zone 2) are defined in each reservoir using 500,000 acre-feet for Lake Buchanan and 600,000 acre-feet for Lake Travis as the zone delineators.
  - (2) When the storage in one reservoir is in Zone 1 (Upper Zone) and the storage in the other reservoir is in Zone 2 (Lower Zone), releases to meet downstream water demands are made from the reservoir with storage in Zone 1 (i.e., from the reservoir that contains more water in storage relative to its conservation storage capacity).

- (3) When both reservoirs are in the same storage zone, a quantity called the “zone storage factor” is calculated for each reservoir that is equal to the percent the zone is full. For example, if both reservoirs are in Zone 1 (Upper Zone) and Lake Travis contains 800,000 acre-feet of water, then the zone storage factor for Lake Travis would be equal to 200,000 (800,000 – 600,000) divided by the volume of Zone 1 in Lake Travis (equal to the full conservation storage capacity minus 600,000).
- (4) When both reservoirs are in Zone 1 (Upper Zone), the zone storage factor for Lake Travis is multiplied by 2, and if this quantity is greater than or equal to the zone storage factor for Lake Buchanan, releases are made from Lake Travis. If this quantity is less than the zone storage factor for Lake Buchanan, then releases are made from Lake Buchanan.
- (5) When both reservoirs are in Zone 2 (Lower Zone), the zone storage factor for Lake Travis is multiplied by 3, and if this quantity is greater than or equal to the zone storage factor for Lake Buchanan, releases are made from Lake Travis. If this quantity is less than the zone storage factor for Lake Buchanan, then releases are made from Lake Buchanan.

## **7. ENVIRONMENTAL INSTREAM FLOW CRITERIA**

- 7.1. The instream flow criteria included in the 2010 WMP are in effect in the baseline WAMs for all decades.
- 7.2. In applying these criteria, the *critical* instream flow criteria are engaged all the time, and the *target* instream flow criteria are engaged when the combined storage in the Buchanan-Travis reservoir system on January 1<sup>st</sup> of any given year exceeds 1.4 million acre-feet.
- 7.3. At any time during any given year when only the *critical* instream flow criteria are engaged, if the combined storage in the Buchanan-Travis reservoir system rises above 1.4 million acre-feet, then the *target* instream flow criteria are re-engaged for the remainder of the year.
- 7.4. After storable inflows are fully utilized, releases of stored water from lakes Buchanan and Travis are made to ensure that the *critical* instream flow criteria are satisfied all of the time.
- 7.5. Only releases of storable inflows to lakes Buchanan and Travis, to the extent they are available, are made to satisfy the *target* instream flow criteria.
- 7.6. In determining the quantity of lakes Buchanan and Travis water required to be released or passed to offset a river flow deficit with regard to a particular instream flow criterion, only the currently-available reliable river flows as defined in Section 2 above, plus any releases from Lake Travis for downstream users, environmental flows, and delivery inefficiencies as defined in §6.6 & §6.7 above (exclusive of any hydropower/emergency scheduling adjustments), that are passing the subject environmental flow location are considered.

## 8. ENVIRONMENTAL BAY INFLOW CRITERIA

- 8.1. The bay and estuary freshwater inflow criteria included in the 2010 WMP are in effect in the baseline WAMs for all decades.
- 8.2. In applying these criteria, the *critical* freshwater inflow criteria are engaged all the time, the *intermediate* freshwater inflow criteria are engaged when the combined storage in the Buchanan-Travis reservoir system on January 1<sup>st</sup> of any given year is greater than 1.1 million acre-feet and less than 1.7 million acre-feet, and the *target* freshwater inflow criteria are engaged when the combined storage in the Buchanan-Travis reservoir system on January 1<sup>st</sup> of any given year exceeds 1.7 million acre-feet.
- 8.3. Once a particular set of freshwater inflow criteria are determined and engaged based on the combined storage in the Buchanan-Travis reservoir system on January 1<sup>st</sup> of a given year, these criteria remain in effect for the entire year regardless of changes in the combined storage in the Buchanan-Travis reservoir system.
- 8.4. Only releases of storable inflows to lakes Buchanan and Travis, to the extent they are available, are made to satisfy these freshwater inflow criteria.
- 8.5. In determining the quantity of lakes Buchanan and Travis water required to be released to offset a freshwater inflow deficit with regard to a particular bay and estuary inflow criterion, the total regulated river inflow to Matagorda Bay is considered.

## 9. SOUTH TEXAS PROJECT

- 9.1. The consumptive demand for the South Texas Project (STP) is set equal to 47,000 ac-ft/year (two generating units) in the 2010 baseline WAM and to 80,125 ac-ft/year (maximum amount authorized in the STP water right) in the 2020 and 2030 WAMs.
- 9.2. The current Water Delivery Plan (WDP) for providing backup water to STP, which was adopted as part of the 2006 Settlement Agreement between LCRA and STP (January 1, 2006), is implemented in the baseline models. As structured, this WDP stipulates that LCRA shall initiate staged deliveries of water to STP from LCRA's available sources upstream of the Bay City Dam when the water surface elevation of STP's main cooling reservoir (MCR) falls below 35 feet MSL, and shall continue such to assist with maintaining the level of the MCR above a minimum elevation of 27 feet MSL.
- 9.3. The WDP does not specifically state how the water deliveries are to be staged with regard to either timing or the quantities to be delivered; it only requires that they commence when the level of the MCR falls below elevation 35 feet MSL. For purposes of implementing a delivery plan in the baseline WAMs, general delivery procedures of a prior water delivery plan are assumed to be followed. These have been incorporated into the WAMs as follows:
  - 1) All backup water provided to STP by LCRA is released directly from the Highland Lakes and is subject to conveyance losses along the lower Colorado River (11.5%), with these conveyance losses borne by LCRA.



- 2) Releases from the Highland Lakes for STP are initiated the first month after the level of STP's MCR falls below 35 feet MSL, which corresponds to a MCR storage volume of 104,630 acre-feet. The initial release rate is 1,200 ac-ft/month.
- 3) As the level of STP's MCR fluctuates below elevation 35 feet MSL, the monthly rate for releasing water from the Highland Lakes is changed in stages, with higher release rates being employed as the level of the MCR falls toward the minimum required operating condition of 27 feet MSL (48,647 acre-feet of storage volume). Maximum releases at the rate of 9,600 ac-ft/month are made when the level of the MCR falls below this elevation. The following table lists the release rates that are engaged in the WAM for different zones of water surface elevation (and storage volume) in the STP's main cooling reservoir.

SURFACE ELEVATION AT TOP OF POOL ZONE Feet MSL	STORAGE VOLUME AT TOP OF POOL ZONE Ac-Ft	TOP AND BOTTOM POOL ZONE ELEVATIONS Feet MSL	RELEASE RATE FROM HIGHLAND LAKES Ac-Ft/Month
49.0	202,600	49.0 to 35.0	0
35.0	104,630	35.0 to 32.0	1,200
32.0	83,636	32.0 to 28.5	2,400
28.5	55,645	28.5 to 27.0	4,800
27.0	48,647	Below 27.0	9,600

- 9.4. In the 2010 and 2020 baseline WAMs, the total supply for STP from run-of-river diversions and backup water from lakes Buchanan and Travis is limited to the 102,000 ac-ft/year stipulated in the STP water right, and the backup supply from the lakes is limited to a rolling 5-year average of 20,000 ac-ft/year in 2010 and a rolling 5-year average of 40,000 ac-ft/year in 2020. In the 2030 baseline WAM, only STP's run-of-river diversions are limited to the 102,000 ac-ft/year stipulated in the STP water right, and the backup supply from the Highland Lakes is limited to a rolling 5-year average of 40,000 ac-ft/year.
- 9.5. The baseline WAMs assume that STP will divert under Certificate of Adjudication 14-5437, whenever the streamflow exceeds the parameters in the certificate without regard to any operational preferences related to salinity or conductivity.

## 10. MISCELLANEOUS

- 10.1. Diversions from the Colorado River authorized under the City of Corpus Christi's Garwood water right are assumed to be zero for 2010, and they are projected at the full authorized diversion amount of 35,000 ac-ft/year for 2020 and 2030. A municipal use monthly demand pattern is assumed for these diversions.
- 10.2. Potential droughts worse than the historical drought of record are not simulated; the baseline WAM's only reflect the period from 1940 to 2009.

**TECHNICAL PAPER A-4**  
**ASSUMPTIONS UNDERLYING WATER AVAILABILITY MODELS**  
**USED TO SUPPORT DEVELOPMENT OF THE**  
**LCRA WATER MANAGEMENT PLAN REVISIONS**  
**January 2012**

Basic assumptions included in the Interim and 2020 versions of the water availability models (WAM) that have been used to support the revision of the Water Management Plan (WMP) for the Lower Colorado River basin are summarized below. The fundamental difference between the Interim WAM and the 2020 WAM relates to the level of water demands specified for LCRA's customers. The 2020 WMP WAM incorporates year-2020 projected demands for all of LCRA's customers and also reflects year-2020 reservoir storage conditions. The Interim WAM incorporates demands for LCRA's municipal, industrial and other firm water customers that represent demands about halfway between the 2010 and 2020 levels, but it includes reservoir storage and irrigation demands for LCRA's lower basin customers that represent 2010 conditions.

**1. GENERAL**

- 1.1. The TCEQ's water availability model of the Colorado River basin (Run 3) forms the basic structure for the LCRA Interim and 2020 WAMs, and this model is assumed to appropriately reflect water rights and hydrologic conditions in the basin to provide for meaningful and accurate simulations of water availability. The Texas A&M University "Water Rights Analysis Package" (WRAP) is the program code used for all WAM simulations.
- 1.2. For purposes of supporting the revision of the WMP, the TCEQ's WAM has been adapted to better represent an operational model of the LCRA's water supply system, including the incorporation of specific operating rules for lakes Buchanan and Travis and for providing water to LCRA's water customers.
- 1.3. The Interim and 2020 WAMs include the "no-call" assumption with regard to all water rights located upstream of the Highland Lakes ("cutoff model").<sup>1</sup> This assumption, in effect, makes all water rights upstream of the Highland Lakes senior in priority to the Highland Lakes and other downstream water rights.
- 1.4. The 1940-1998 monthly naturalized flows and net evaporation rates included in the TCEQ's Run 3 WAM for the Colorado River basin have been extended through calendar year 2009<sup>2</sup>, and this extended database is used to define the simulation period for the Interim and 2020 WAMs. These data are assumed to be representative of actual

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<sup>1</sup> The "no-call" assumption in the WAM is an attempt to reflect the various agreements that LCRA has with upstream reservoir owners, i.e. Colorado River Municipal Water District, San Angelo Water Supply Corporation, and Brown County WID No. 1, and to better represent actual conditions with regard to the operation of existing water rights throughout the basin.

<sup>2</sup> The naturalized flows for the 1999-2009 period were developed by LCRA using the same methodology applied in developing the original WAM for the Colorado River Basin.

variations in hydrologic conditions sufficient to support meaningful and accurate simulations of water availability, including the 1950s drought of record.

- 1.5. Water demands for all surface water users in the Colorado River basin that are not partially or wholly supplied by LCRA's water delivery system (the Highland Lakes and LCRA's lower basin water rights) are conservatively assumed to be equal to the maximum annual diversion amounts authorized by their individual water rights as reflected in TCEQ's Run 3 WAM.

## 2. LOWER BASIN RELIABLE RUN-OF-RIVER SUPPLIES

- 2.1. In the Interim and 2020 WAMs, to more accurately reflect the actual quantity of releases (inflow pass-throughs and stored water) from lakes Buchanan and Travis needed to meet LCRA's downstream irrigation demands and to supply certain other customers in a manner consistent with historical operations, the supply of run-of-river water originating downstream of Mansfield Dam that is assumed available for diversion by these water users is limited to quantities that historically have proven to be reliable considering base flows in the lower segments of the Colorado River that are sustained with groundwater inflows and the return flows discharged from the City of Austin's wastewater treatment plants.<sup>3</sup>
- 2.2. The base flow portions of these downstream reliable river flows have been determined by LCRA staff for specific reaches of the river, and these quantities are stipulated in the Interim and 2020 WAMs as follows:

Mansfield Dam to Austin gage	2,600 ac-ft/month
Austin gage to Bastrop gage	0 ac-ft/month
Bastrop gage to Columbus gage	3,900 ac-ft/month
Columbus gage to Wharton gage	3,133 ac-ft/month
Wharton gage to Bay City gage	1,567 ac-ft/month

Hence, with regard to flows originating downstream of Mansfield Dam, there is a maximum of only 11,200 acre-feet of base flows plus Austin's return flows in any given month that are assumed to be reliably available for supplying LCRA's downstream irrigation demands and certain other water supply customers.

- 2.3. In addition to LCRA's irrigation demands at the four downstream irrigation operations, the run-of-river diversions of Austin at the Fayette Power Plant and the City of Corpus Christi's Garwood water right also are subject to the availability of the reliable downstream river flows.
- 2.4. Prior to any diversions being made, the total quantity of reliable downstream river flow at any location along the lower Colorado River is equal to the sum of Austin's return

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<sup>3</sup> This limitation on available flows in the lower Colorado River is considered to be appropriate based on LCRA's historical operational experience attempting to provide inflows and stored water from the Highland Lakes to downstream water users on a daily basis while also taking into consideration the actual river flows in the lower basin that can be effectively diverted on a daily basis by the lower basin water users.

flows and the sum of the incremental reliable river flows that originate in each of the upstream reaches of the river.

- 2.5. The total quantity of reliable downstream river flow at any location along the lower Colorado River is reduced as diversions are made upstream in priority order by the individual irrigation operations, Austin at the Fayette Power Plant, and the City of Corpus Christi's Garwood water right at their respective diversion points.

### **3. MUNICIPAL, INDUSTRIAL, POWER GENERATION AND OTHER FIRM DEMANDS**

- 3.1. For the Interim WAM, municipal, industrial, power generation and other firm water demands partially or wholly supplied by LCRA's water represent 2010-2020 interim conditions (about half-way between 2010 and 2020 levels of firm demands). For the 2020 WAM, the municipal, industrial, power generation and other firm power demands represent year-2020 projected conditions.
- 3.2. For both the Interim and 2020 WAMs, the following demands are included:
  - 3.2.1. Firm demands of 6,000 ac-ft/year in the Interim WAM and 7,000 ac-ft/year in the 2020 WAM for domestic water use are included as direct diversions from the Highland Lakes. These demands have been separated out from other demands. To date, LCRA has issued a significant number of firm water contracts for domestic use. Although LCRA has not issued contracts for all of this water, and most, if not all diverters from the Highland Lakes do not have a legal right to divert absent a contract, LCRA recognizes that this demand exists, and that the number of contracts for domestic use has increased. Thus, LCRA has included the full amount of estimated domestic use in model simulations.
  - 3.2.2. A firm demand of 20,000 ac-ft/year on the Highland Lakes is included in both the Interim and 2020 WAMs as releases from the lakes Buchanan and Travis to represent the adjustments to account for changes in hydropower scheduling and other emergency releases from Lake Travis.
- 3.3. Based on projections of anticipated population growth and increases in manufacturing, industrial and electrical generation water needs developed by LCRA staff pursuant to the development of the LCRA Water Resource Supply Plan and additional input from City of Austin staff, the following demands for the City of Austin are included in the models:
  - 3.3.1. Austin's projected M&I demands are 193,334 ac-ft/year in the Interim WAM and 203,880 ac-ft/year in 2020 WAM and are met first from the City's Certificate of Adjudication 14-5471, as amended, with stored water backup from LCRA's lakes Buchanan and Travis. The above interim and 2020 demands do not include any direct reuse. Direct reuse demands are supplied in a given month from the return flows generated the previous month from Austin municipal demands.

- 3.3.2. An irrigation demand equal to 13,620 ac-ft/year has also been included in both the Interim and 2020 WAMs for Austin which is satisfied entirely through direct reuse of Austin's treated wastewater effluent.
- 3.3.3. Demands for Austin's Sand Hill power plant have been set as follows, with these projected demands satisfied from the indicated sources (with no backup using LCRA's lakes Buchanan and Travis water):

<u>Source of Supply</u>	<u>Interim WAM ac-ft/yr</u>	<u>2020 WAM ac-ft/yr</u>
Direct Reuse of Austin's WW Effluent	3,315	3,315
Austin's Certificate of Adjudication 14-5471	<u>843</u>	<u>1,685</u>
Total Demand	4,158	5,000

- 3.3.4. Demands for Austin's Decker power plant have been projected at 9,250 ac-ft/year for the interim condition (Interim WAM) and 13,500 ac-ft/year for 2020 (2020 WAM), with these demands satisfied first using Austin's Decker water right (Certificate of Adjudication 14-5489, as amended), then backed up to these amounts with LCRA's lakes Buchanan and Travis water consistent with the 1999 Agreement.
- 3.3.5. Demands for Austin at Fayette Power Plant are projected at 11,601 for the interim condition (Interim WAM) and 14,702 ac-ft/year for 2020 (2020 WAM) with these demands satisfied first using Austin's Certificate of Adjudication 14-5471, as amended, and subject to available reliable downstream river flows as per Sections 2.2 & 2.3 above, then backed up entirely with LCRA's Highland Lakes water consistent with LCRA's separate contract with Austin for FPP.
- 3.3.6. The Lady Bird Lake portion of Austin's Certificate of Adjudication 14-5471, as amended, (subject to available reliable downstream river flows as per Sections 2.2 & 2.3 above) is used first to satisfy demands for Austin at Fayette Power Plant and then to satisfy the demands for Austin's Sand Hills power plant, with the sum of these diversions limited to 24,000 ac-ft/year.
- 3.4. For both the Interim and 2020 WAMs, all of the municipal, industrial, power generation and other firm water demands that are provided water from LCRA are satisfied either entirely with stored water directly from lakes Buchanan and Travis or with run-of-river diversions backed up with stored water from lakes Buchanan and Travis.
- 3.5. For both the Interim and 2020 WAMs, with the exception of Austin's Sand Hill power plant run-of-river demand as noted above, all of the municipal, industrial, power generation and other firm water demands supplied by LCRA's water are fully satisfied (firm).
- 3.6. For both the Interim and 2020 WAMs, all of the M&I demands that are provided water from LCRA's water are subject to reduction as mandatory drought water use restrictions under the firm customers' drought contingency plans are implemented. This is triggered in months when the combined storage in lakes Buchanan and Travis is below 600,000 acre-feet. Under this reduction plan, the M&I demands are reduced by 10% for the months when this occurs.

#### 4. CITY OF AUSTIN RETURN FLOWS

4.1. For both the Interim and 2020 WAMs, return flows discharged from the City of Austin's wastewater treatment plants into the Colorado River are determined using procedures consistent with those employed by the Region K Water Planning Group and involve the following calculations:

- At the end of each monthly time step during a WAM simulation, the total amount of Colorado River diversions made by the City of Austin to satisfy its M&I water demands is recorded.
- The total quantity of treated wastewater effluent associated with Austin's total M&I river diversions then is calculated by applying the corresponding monthly factor from the following table to Austin's total amount of M&I river diversions. These factors were derived based on Austin's actual river diversions and return flows reported for the 2000-2005 period.

Jan	Feb	Mar	Apr	May	Jun
0.7873	0.8027	0.7994	0.6487	0.5509	0.5379
Jul	Aug	Sep	Oct	Nov	Dec
0.4597	0.4213	0.4821	0.5806	0.7215	0.7735

- At the beginning of the following time step, the calculated amount of Austin's treated wastewater effluent from the previous time step is reduced by the amount of Austin's demand that is expected to be satisfied by direct reuse for irrigation and for the Sand Hill power plant.
  - The remaining reduced quantity represents the total amount of return flows that is discharged to the Colorado River at the beginning of the current time step.
- 4.2. For the Interim and 2020 WAMs, no indirect reuse of Austin's return flows is included in the models because the City of Austin has not identified any indirect reuse projects in the 2011 Region K Plan through at least the year 2060; consequently, all of Austin's return flows, except those identified above as being directly reused, are discharged to the river and are available for use by all downstream water users in accordance with the prior appropriation doctrine and consistent with the 2007 Settlement Agreement.

#### 5. LCRA IRRIGATION DEMANDS

- 5.1. Water demands associated with the four downstream irrigation operations (Garwood, Lakeside, Pierce Ranch and Gulf Coast) corresponding to year-2010 and year-2020 conditions in the Interim and 2020 WAMs, respectively, have been projected by LCRA staff taking into consideration the Region K projections, with adjustments derived from actual historical data for the past 20 years to incorporate historical climatic variations in the demands on an annual basis.
- 5.2. First and second crop acreages (uncurtailed planted acreage) have been adjusted to maintain the historical split based on 2006 to 2010 data for each irrigation operation. The percentages of second crop to first crop acreages for Garwood, Lakeside, Pierce

Ranch and Gulf Coast for this period were 82%, 58%, 74% and 63%, respectively. A generalized pattern of monthly use for irrigation has been applied to the annual demand quantities to derive monthly demand estimates for each year of the 1940-2009 simulation period used in the Interim and 2020 WAMs.

- 5.3. Water demands associated with the four downstream irrigation operations are satisfied with available run-of-river supplies originating downstream of Mansfield Dam first, then with available inflows passed through the Highland Lakes, and finally, in many cases, with interruptible stored water from lakes Buchanan and Travis.
- 5.4. The supply of run-of-river water originating downstream of Mansfield Dam that is assumed to be available for diversion by the downstream irrigation operations is limited to the available supply of reliable river flows as described in Section 2 above.
- 5.5. Lakes Buchanan and Travis water supplies for the downstream irrigation operations in the lower basin are subject to curtailment in accordance with general curtailment procedures evaluated in the Water Management Plan Revision Advisory Committee process, with the degree of curtailment dependent upon the quantity of water stored in lakes Buchanan and Travis on January 1<sup>st</sup> of each year for the first crop and the quantity of water stored in lakes Buchanan and Travis on June 1<sup>st</sup> of each year for the second crop. Once the degrees of curtailment are determined, corresponding but separate demand factors are applied to reduce the monthly demand values for the second and first crops, respectively, in order to achieve the appropriate levels of curtailment.
- 5.6. After the initial demand factors are established during the months of January and June of each year, an additional check of the quantity of water stored in lakes Buchanan and Travis is made at the beginning of March for the first crop supply and at the beginning of August for the second crop supply. The first crop re-check of system storage in March is used only to increase the demand factors applied to the first crop if the Buchanan-Travis system storage has increased since January 1<sup>st</sup>. The second crop re-check of system storage in August also is used as a one-way upward adjustment, increasing the demand factors applied to the second crop if the Buchanan-Travis system storage indicates an increase since the June check, but maintaining the factors derived from the June check if the system storage decreases since the June check.
- 5.7. When the combined storage in lakes Buchanan and Travis is above 650,000 acre-feet on January 1<sup>st</sup> of any year or 600,000 acre-feet at any time, the available supply of water from lakes Buchanan and Travis for the Garwood irrigation operation (and its demands) is assumed to not be curtailed. This conservative assumption is based upon historically high reliability of the Garwood water right and corresponding low demand for backup water under historic hydrologic conditions. However Garwood supplies could be curtailed under future hydrologic conditions or conditions other than those simulated under this WMP, such as a recurrence of the extreme dry conditions from year 2011. As this technical paper was being finalized there exists a significant chance of such a curtailment in 2012. If the combined storage in the reservoirs is below 650,000 acre-feet on January 1<sup>st</sup> of any year or 600,000 acre-feet at any time, then the available supply of water for the Garwood irrigation operation from above Mansfield Dam is limited to only the inflows to the Highland Lakes to which the Garwood water

right is entitled. The above procedures are applied in both the Interim and 2020 WAMs.

- 5.8. For the non-Garwood irrigation operations (Lakeside, Pierce Ranch and Gulf Coast), curtailment is structured differently in the Interim and 2020 WAMs. It should be noted that although demands are not curtailed in these model runs when storage is above a given level (as described below), in actual operation, curtailments could be experienced if, for example, the requested acreage or demands exceed the demands simulated in these models.
  - 5.8.1. For the Interim WAM, the available supply of lakes Buchanan and Travis water for the first crop is never curtailed as long as the combined storage in lakes Buchanan and Travis on January 1<sup>st</sup> of any year is above or equal to 1,400,000 acre-feet. Curtailment of the first crop supply (actually in the WAM curtailment is achieved by reducing the first crop demands) occurs when the combined storage is at or below 1,399,999 acre-feet, increasing linearly from a 10% curtailment factor at 1,399,999 acre-feet up to a curtailment factor of 30% at 1,000,000 acre-feet of combined storage. From 1,000,000 acre-feet of combined storage down to 650,000 acre-feet, the curtailment factor is maintained at 30%. When the combined system storage is below 650,000 acre-feet, demands for the first crop are set to zero.
  - 5.8.2. For the Interim WAM, the available supply of lakes Buchanan and Travis water for the second crop is not curtailed as long as the combined storage in lakes Buchanan and Travis on June 1<sup>st</sup> of any year is above or equal to 1,550,000 acre-feet. Curtailment of the second crop supply (actually the WAM curtailment is achieved by reducing the second crop demands) occurs when the combined storage is at or below 1,549,999 acre-feet, increasing linearly from a 10% curtailment factor at 1,549,999 acre-feet of combined storage up to a curtailment factor of 50% at 1,000,000 acre-feet of combined storage. From 1,000,000 acre-feet of combined storage down to 900,000 acre-feet, the curtailment factor is maintained at 50%. When the combined system storage falls below 900,000 acre-feet, demands for the second crop are set to zero.
  - 5.8.3. For the 2020 WAM, the available supply of lakes Buchanan and Travis water for the first crop is not curtailed as long as the combined storage in lakes Buchanan and Travis on January 1<sup>st</sup> of any year is above 1,400,000 acre-feet. Curtailment of the first crop supply (actually reduction of the first crop demands in the WAM) occurs when the combined storage is at or below 1,399,999 acre-feet, increasing linearly from a 10% curtailment factor at 1,399,999 acre-feet up to a curtailment factor of 35% at 1,100,000 acre-feet of combined storage. From 1,099,999 acre-feet of combined storage down to 650,000 acre-feet, the curtailment factor is maintained at 50%. When the combined system storage is below 650,000 acre-feet, demands for the first crop are set to zero.
  - 5.8.4. For the 2020 WAM, the available supply of lakes Buchanan and Travis water for the second crop is not curtailed as long as the combined storage in lakes Buchanan and Travis on June 1<sup>st</sup> of any year is above 1,550,000 acre-feet. Curtailment of the second crop supply (actually reduction of the second crop



demands in the WAM) occurs when the combined storage is at or below 1,549,999 acre-feet, increasing linearly from a 10% curtailment factor at 1,549,999 acre-feet of combined storage up to a curtailment factor of 35% at 1,300,000 acre-feet of combined storage. From 1,299,999 acre-feet of combined storage down to 1,200,000 acre-feet, the curtailment factor is maintained at 50%. When the combined system storage falls below 1,200,000 acre-feet, demands for the second crop are set to zero.

- 5.9. Below 650,000 acre-feet of combined storage in lakes Buchanan and Travis on January 1<sup>st</sup> of any year, no stored water is provided from lakes Buchanan and Travis for any of the irrigation operations for the entire year. Likewise, when the combined storage in lakes Buchanan and Travis at any time falls below 600,000 ac-ft, no stored water is made available for satisfying the demands of any of the irrigation operations from lakes Buchanan and Travis.
- 5.10. Return flows to the Colorado River from the downstream irrigation operations are discharged at the end of the last month of each crop season (June for 1<sup>st</sup> crop and October for 2<sup>nd</sup> crop), after all irrigation diversion activities have been completed, with these return flows calculated based on the following percentages of the total water supply utilized by each of the irrigation operations during that month:

Garwood	3 %	Lakeside	2 %
Pierce Ranch	18 %	Gulf Coast	10 %

## 6. HIGHLAND LAKES STORAGE AND RELEASES

- 6.1. Based on recent sedimentation studies conducted by the Texas Water Development Board (TWDB) and extrapolation of these data by LCRA to the year 2020, the combined conservation storage capacity of lakes Buchanan and Travis is projected to continue to decrease due to sedimentation from 2,008,028 acre-feet in 2010 to approximately 2,000,487 acre-feet in 2020.
- 6.2. The conservation storage capacity of Lake Buchanan at elevation 1020 feet msl is expected to decrease from approximately 873,572 acre-feet in 2010 down to approximately 868,531 acre-feet in 2020.
- 6.3. The conservation storage capacity of Lake Travis at elevation 681 feet msl is projected to decrease from approximately 1,134,456 acre-feet in 2010 down to approximately 1,131,956 acre-feet in 2020.
- 6.4. To reflect expected future operating procedures during the timeframe of this WMP due to an on-going dam modification project, the top of the conservation pool for Lake Buchanan is set at a constant of 1018 feet msl in both the Interim and 2020 WAMs.
- 6.5. To be consistent with current LCRA operations and accounting procedures, the quantity referred to as “storable inflows” to lakes Buchanan and Travis is determined in both the Interim and 2020 WAMs as the volume of available inflows that is capable of being stored in the reservoirs at the 1926 priority date immediately after inflows to the reservoirs have been passed downstream to satisfy the demands of senior water rights. The storable inflows quantity is the amount of inflows made available to satisfy

environmental flow needs, except that stored water also is made available for satisfying Subsistence instream flow needs, if necessary.

- 6.6. Requirements for releases from lakes Buchanan and Travis to satisfy the demands of LCRA's downstream M&I water users below La Grange are increased by the following factors to account for delivery losses along the lower Colorado River, and once such carrying water passes the associated points of diversion, it is available for diversion and use by all downstream users, with the exception of those demands whose run-of-the-river supplies are limited to the reliable downstream river flows as described in Section 2 above, i.e., the LCRA irrigation operations, Austin's Fayette Power Plant demand, and the Corpus Christi Garwood demand.

<u>Diverter</u>	<u>Delivery Factor</u>
Fayette Power Plant	6.5 %
Matagorda County Industrial/Power Generation	10.9 %
South Texas Project	11.5 %

- 6.7. Requirements for releases from lakes Buchanan and Travis to satisfy the demands of the downstream irrigation operations (to the extent there are demands for a particular month) are increased by the following monthly delivery factors to account for delivery losses along the lower Colorado River and for water that was ordered to meet requested demands but was not diverted due to weather or other circumstances. Once such ordered water passes the associated points of diversion, it is available for diversion and use by all downstream water rights, with the exception of those demands whose run-of-the-river supplies are limited to the reliable downstream river flows as described in Section 2 above, i.e., the downstream irrigation operations, Austin's Fayette Power Plant demand, and the Corpus Christi Garwood demand.

<u>Month</u>	<u>Garwood</u>	<u>Gulf Coast</u>	<u>Lakeside</u>	<u>Pierce Ranch</u>
January	n/a	n/a	n/a	n/a
February	n/a	n/a	n/a	n/a
March	20 %	17 %	263 %	38 %
April	106 %	53 %	242 %	91 %
May	28 %	6 %	23 %	32 %
June	26 %	11 %	38 %	38 %
July	75 %	39 %	93 %	160 %
August	24 %	10 %	46 %	32 %
September	43 %	33 %	88 %	71 %
October	62 %	18 %	78 %	139 %
November	n/a	n/a	n/a	23 %
December	n/a	n/a	n/a	n/a

- 6.8. Releases from the lakes Buchanan and Travis that are made to reflect the adjustment to releases associated with hydropower scheduling and other emergency releases are available only for diversion by the South Texas Project under its run-of-river water right, and they are not accounted for in downstream river flows when determining the

required releases from the lakes Buchanan and Travis for satisfying instream flow requirements.

- 6.9. Releases of stored water from Lake Buchanan are made to maintain the intervening Highland Lakes (Lake Inks, Lake LBJ, and Lake Marble Falls) within an established operating range at all times. In addition, releases of stored water from Lake Travis are made to maintain Lake Austin and Lady Bird Lake within an established operating range.
- 6.10. Procedures in the WAMs for making releases from either Lake Buchanan or Lake Travis to meet downstream water demands use the reservoir system operating rules that are embedded in the basic WRAP program. At any time, the relative storage conditions of the two reservoirs determine from which reservoir releases are to be made, with the overall objective of using water from Lake Travis at a somewhat higher rate than from Lake Buchanan in order to minimize flood spills from Lake Travis when Lake Buchanan is not full and to ensure that water stored in Lake Travis is fully utilized before the last release is made from Lake Buchanan when and if the reservoir system becomes fully depleted. Procedures for making releases under the current reservoir operating rules in the WAMs for Lakes Buchanan and Travis in the WAMs are as follows:
  - (1) An Upper Zone (Zone 1) and a Lower Zone (Zone 2) are defined in each reservoir using 500,000 acre-feet for Lake Buchanan and 600,000 acre-feet for Lake Travis as the zone delineators.
  - (2) When the storage in one reservoir is in Zone 1 (Upper Zone) and the storage in the other reservoir is in Zone 2 (Lower Zone), releases to meet downstream water demands are made from the reservoir with storage in Zone 1 (i.e., from the reservoir that contains more water in storage relative to its conservation storage capacity).
  - (3) When both reservoirs are in the same storage zone, a quantity called the “zone storage factor” is calculated for each reservoir that is equal to the percent the zone is full. For example, if both reservoirs are in Zone 1 (Upper Zone) and Lake Travis contains 800,000 acre-feet of water, then the zone storage factor for Lake Travis would be equal to 200,000 (800,000 – 600,000) divided by the volume of Zone 1 in Lake Travis (equal to the full conservation storage capacity minus 600,000).
  - (4) When both reservoirs are in Zone 1 (Upper Zone), the zone storage factor for Lake Travis is multiplied by 2, and if this quantity is greater than or equal to the zone storage factor for Lake Buchanan, releases are made from Lake Travis. If this quantity is less than the zone storage factor for Lake Buchanan, then releases are made from Lake Buchanan.
  - (5) When both reservoirs are in Zone 2 (Lower Zone), the zone storage factor for Lake Travis is multiplied by 3, and if this quantity is greater than or equal to the zone storage factor for Lake Buchanan, releases are made from Lake Travis. If this quantity is less than the zone storage factor for Lake Buchanan, then releases are made from Lake Buchanan.

## **7. ENVIRONMENTAL INSTREAM FLOW CRITERIA**

- 7.1. The Subsistence, Base Dry and Base Average instream flow criteria described in Lower Colorado River, Texas, Instream Flow Guidelines (2008)<sup>4</sup> are in effect in both the Interim and 2020 WAMs at the gages on the Colorado River at Austin, Bastrop, Columbus and Wharton.
- 7.2. In applying these criteria, the Subsistence instream flow criteria are engaged all the time. The engagement of the Base Dry and the Base Average instream flow criteria is determined based on the combined storage in the Buchanan-Travis reservoir system on January 1<sup>st</sup> and June 1<sup>st</sup> of any given year. If the combined storage exceeds 1,900,000 acre-feet, then the Base Dry criteria are engaged; otherwise, they are disengaged. If the combined storage exceeds 1,960,000 acre-feet, then the Base Average criteria are engaged; otherwise, they are disengaged.
- 7.3. After storable inflows are fully utilized, releases of stored water from lakes Buchanan and Travis are made to help satisfy the Subsistence instream flow criteria all of the time.
- 7.4. Only releases of storable inflows to lakes Buchanan and Travis, to the extent they are available, are made to help satisfy the Base Dry and Base Average instream flow criteria.
- 7.5. In determining the quantity of lakes Buchanan and Travis water required to be released or passed to offset a river flow deficit with regard to a particular instream flow criterion, only the currently-available reliable river flows as defined in Section 2 above, plus any releases from lakes Buchanan and Travis for downstream users, environmental flows, and delivery inefficiencies as defined in Sections 6.6 & 6.7 above (exclusive of any hydropower/emergency scheduling adjustments), that are passing the subject environmental flow location are considered.
- 7.6. The WAM is based on a monthly time step. Intra-daily or instantaneous flows were not simulated.

## **8. ENVIRONMENTAL BAY INFLOW CRITERIA**

- 8.1. The requirements for passing Colorado River flows to Matagorda Bay are based on the recommendations of the Matagorda Bay Health Evaluation (MBHE) study<sup>5</sup>, and have been operationalized for use in the Water Management Plan revision. The environmental requirements in the Interim and 2020 WAMs are based on two-month volumes of inflows with subsequent adjustments if the three-month seasonal bay inflow recommendations of the MBHE study have already been satisfied.

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<sup>4</sup> BIO-WEST, Inc. (2008); Lower Colorado River, Texas, Instream Flow Guidelines, Colorado River Flow Relationships to Aquatic Habitat and State Threatened Species: Blue Sucker; prepared for Lower Colorado River Authority and San Antonio Water System; Round Rock, Texas.

<sup>5</sup> Lower Colorado River Authority and San Antonio Water System (2008); Final Report, Matagorda Bay Inflow Criteria (Colorado River), Matagorda Bay Health Evaluation; Austin, Texas.

- 8.2. The two-month bay inflow needs as included in the Interim and 2020 WAMs vary by season according to the amount of combined storage in lakes Buchanan and Travis as of January 1st for the Spring season and as of June 1st for the Fall season. The Intervening Period covers those months not included in either the Spring or Fall seasons, and the combined storage in lakes Buchanan and Travis as of June 1st also determines the two-month bay inflow needs for this period. For example, for the month of March, for the MBHE Operational Inflow Level 1 criteria of 76,000 acre-feet to be satisfied, the total inflows for the month of February and March must equal or exceed 76,000 acre-feet. This two month target is repeated in the months of April, May and June, such that for the criteria to be satisfied, the total of the current month and preceding month must equal or exceed 76,000 acre-feet. The different two-month bay inflow needs are listed in the following table by season or period with their associated Buchanan-Travis storage zones.

MBHE Operational Inflow Level	Two-Month Bay Inflow Need (ac-ft)			Associated Buchanan-Travis Storage Zones (million ac-ft)	
	Spring Season March-June	Fall Season July-Oct	Intervening Period Nov-Feb	Interim	2020
Level-1	76,000	54,000	35,000	1.00 - 1.30	1.00 - 1.70
Level-2	112,000	80,000	52,000	1.30 - 1.50	1.70 - 1.80
Level-3	164,000	117,000	76,000	1.50 - 1.95	1.80 - 1.95
Level-4	289,000	205,000	133,000	1.95 - Full	1.95 - Full

- 8.3. Under the operational methodology, a minimum Threshold bay inflow requirement of 15,000 ac-ft/month must be satisfied every month, including those months when the combined storage in lakes Buchanan and Travis is less than the minimum storage zone for Level-1, and to the extent available river inflows, entering the river below Longhorn Dam, are not adequate to meet this requirement, storable inflows to the Highland Lakes are passed through the reservoirs downstream to the bay to help satisfy the Threshold requirement, regardless of the combined storage of lakes Buchanan and Travis or the season of the year. Previously stored water is not released to meet freshwater inflow targets.
- 8.4. For engaging the operational criteria in both the Interim and 2020 WAMs, the combined storage in lakes Buchanan and Travis as of January 1st is used to establish the two-month bay inflow needs at the end of the subsequent months of March, April, May and June. Similarly, the June 1st combined storage in lakes Buchanan and Travis is used to establish the two-month bay inflow needs at the end of the subsequent months of July through February. At the end of each of these months during the WAM simulations, the volume of additional inflow beyond the available river inflow that is required to fully satisfy the two-month bay inflow need is released from the available storable inflows to the Highland Lakes. An exception to this procedure is noted below.
- 8.5. For the months of May and June during the Spring season and September and October during the Fall season, an additional check is made to determine if the three-month

cumulative inflow to the bay has satisfied the corresponding MBHE three-month bay inflow requirement. If it has, then the effective two-month bay inflow need for the particular month is set equal to the two month intervening bay inflow need for the corresponding MBHE Operational Inflow Level. The relevant MBHE three-month bay inflow requirements, after rounding, corresponding to the four different MBHE inflow levels (and their associated Buchanan-Travis combined storage zones) for the three-month periods ending in May and June and September and October are listed in the following table. It should be noted that this check against the MBHE bay inflow recommendations in the Interim and 2020 WAMs is made for only the complete three-month consecutive periods that fall within the MBHE Operational seasons as defined above.

MBHE Inflow ID	<u>MBHE 3-Month Bay Inflow Need (ac-ft)</u>	
	Spring Season	Fall Season
MBHE-1	114,000	81,000
MBHE-2	169,000	120,000
MBHE-3	246,000	175,000
MBHE-4	433,000	308,000

- 8.6. On a monthly basis, only releases of storable inflows to lakes Buchanan and Travis, to the extent they are available, are made to help satisfy these freshwater inflow needs. Previously stored water is not released to meet freshwater inflow targets.
- 8.7. In determining the quantity of Highland Lakes water required to be released to offset a freshwater inflow deficit with regard to a particular bay inflow need, the total regulated river inflow to Matagorda Bay is considered.

## 9. SOUTH TEXAS PROJECT

- 9.1. The consumptive demand for South Texas Project (STP) is set equal to 47,000 ac-ft/year (two generating units) in the Interim WAM (2010-2020 interim demand) and to 80,125 ac-ft/year (maximum amount authorized in the STP water right) in the 2020 WAM (2020 demand).
- 9.2. The current Water Delivery Plan (WDP) for providing backup water to STP, which was adopted as part of the 2006 Settlement Agreement between LCRA and STP (January 1, 2006), is implemented in the Interim and 2020 WAMs. As structured, this WDP stipulates that LCRA shall initiate staged deliveries of water to STP from LCRA's available sources upstream of the Bay City Dam when the water surface elevation of STP's main cooling reservoir (MCR) falls below 35 feet MSL. Under the WDP, deliveries are continued to be made to assist with maintaining the level of the MCR above a minimum elevation of 27 feet MSL.
- 9.3. The WDP does not specifically state how the water deliveries are to be staged with regard to either timing or the quantities to be delivered; it only requires that they

commence when the level of the MCR falls below elevation 35 feet MSL. The operating procedures for delivery of water is assumed to be consistent with the previous water delivery plan as described in Technical Paper A-3, Assumptions Underlying LCRA 2010 WMP Baseline Water Availability Model, found in Appendix A.

- 9.4. In both the Interim and 2020 WAMs, the total supply for STP from run-of-river diversions and backup water from lakes Buchanan and Travis is limited to the 102,000 ac-ft/year stipulated in the STP water right, and the backup supply from the lakes is limited to a rolling 5-year average of 20,000 ac-ft/year in the Interim WAM and a rolling 5-year average of 40,000 ac-ft/year in the 2020 WAM.
- 9.5. The Interim and 2020 WAMs assume that STP will divert under Certificate of Adjudication 14-5437, whenever the streamflow exceeds the parameters in the certificate without regard to any operational preferences related to salinity or conductivity.

## **10. MISCELLANEOUS**

- 10.1. Diversions from the Colorado River authorized under the City of Corpus Christi's Garwood water right are assumed to be zero in the Interim WAM, and they are projected at the full authorized diversion amount of 35,000 ac-ft/year in the 2020 WAM. A municipal use monthly demand pattern is assumed for these diversions.
- 10.2. Deliveries from lakes Buchanan and Travis by LCRA for a potential power plant in Matagorda County are made monthly to satisfy an annual demand of 12,870 ac-ft/year in the Interim WAM and an annual demand of 25,740 ac-ft/year in the 2020 WAM. A monthly demand pattern corresponding to power generation is assumed for these deliveries.
- 10.3. Potential droughts worse than the historical drought of record are not simulated; the Interim and 2020 WAMs reflect only the period from 1940 to 2009.

**TECHNICAL PAPER A-5**  
**DEVELOPMENT OF COMBINED FIRM YIELD**  
**OF LAKES BUCHANAN AND TRAVIS**  
**January 2012**

## **1.0 INTRODUCTION**

The Final Judgment and Decree relating to the adjudication of water rights for the Lower Colorado River Authority (LCRA) and the City of Austin, which was issued on April 20, 1988 in the 264th Judicial District Court of Bell County, Texas, requires LCRA, pursuant to provisions in its Certificates of Adjudication 14-5478 and 14-5482 that authorize lakes Buchanan and Travis, respectively, to determine the "combined firm yield" of lakes Buchanan and Travis when operated as a reservoir system. As stipulated in Paragraph 2.B(6) of the Buchanan and Travis Certificates, the combined firm yield value represents the maximum amount of water that LCRA can commit to supply annually on a firm, uninterruptible basis to its customers.

For purposes of the Water Management Plan (WMP), the combined firm yield<sup>1</sup> of lakes Buchanan and Travis is defined as:

*That amount of water the reservoir could have produced annually if it had been in place during the worst drought of record. In performing this simulation, naturalized streamflows will be modified as appropriate to account for the full exercise of upstream senior water rights is assumed as well as the passage of sufficient water to satisfy all downstream senior water rights valued at their full authorized amounts and conditions as well as the passage of flows needed to meet all applicable permit conditions relating to instream and freshwater inflow requirements.<sup>2</sup>*

As described more fully in Section 3.1.2 of this paper, for purposes of this WMP, the combined firm yield calculation employs a cutoff assumption with respect to portions of the upper basin, including above O.H. Ivie Reservoir, similar to previous calculations.

The concept of firm yield of a reservoir or system of reservoirs is fundamental to water supply planning in that it defines what is considered to be a reliable level of supply that can be reasonably expected to be available in the future should a drought occur that is no more severe than the worst drought recorded by historical data. While the worst drought of record generally is characterized by the period of lowest recorded rainfall and streamflow as these factors determine the minimum supply of water available within a particular watershed, the amount of available reservoir storage capacity and how the available supply of water is actually used also can greatly influence when a severe drought begins and when it ends. It is also possible for a drought more severe than the drought of record to occur in the future, in which case the firm

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<sup>1</sup> The 1988 Final Judgment and Decree also referred to the Combined Theoretical Yield, the yield of lakes Buchanan and Travis if: 1) there were no other impoundment, diversion or use of the flows of the Colorado River and its tributaries upstream; 2) no portion of the inflows to lakes Buchanan and Travis is passed to honor downstream senior water rights; and 3) Lakes Buchanan and Travis are operated as a system. For this WMP revision, the Combined Theoretical Yield has not been calculated.

<sup>2</sup> 30 Tex. Admin. Code § 297.1(20).



yield amount based on the previous historical drought of record would not be available from a reservoir or reservoir system.

## **2.0 COMBINED FIRM YIELD DETERMINATION**

The approach for determining the combined firm yield of the Buchanan-Travis reservoir system involves application of the water availability model (WAM) of the Colorado River Basin that was developed by the Texas Natural Resource Conservation Commission, the predecessor agency to the Texas Commission on Environmental Quality (TCEQ), in 2001 pursuant to Senate Bill 1 (75th Texas Legislature). This WAM accounts individually for each of the existing surface water rights in the Colorado River Basin, including those that authorize lakes Buchanan and Travis. Using monthly values of streamflow throughout the basin corresponding to historical hydrologic and climatic conditions, the WAM simulates on a monthly basis the supply, or volume, of surface water that is available to satisfy the authorized diversion amount for each individual water right.

In the WAM's monthly simulation process, individual water rights are considered in priority order in accordance with the prior appropriation doctrine, i.e., water is provided to the oldest (or most senior) water right first during times of shortage. Water rights are prioritized according to their priority date, which generally corresponds to the date a particular water right was issued by the State, or for some older rights, the first date when actual surface water usage was documented.

Each of the reservoirs in the Highland Lakes chain is represented in the WAM for the Colorado River Basin. Demands for water from lakes Buchanan and Travis are specified in the model in accordance with authorized uses and, in some cases, consistent with contractual agreements between LCRA and its customers. For example, the contractual demand for backup water from lakes Buchanan and Travis for the City of Austin's water rights to provide a firm supply for the City's municipal and industrial customers is included in the WAM. For the combined firm yield analysis, the total annual demand amount specified in the WAM for the Buchanan-Travis reservoir system is, by definition, equal to the combined firm yield of the reservoirs. This quantity is determined through an iterative process whereby multiple simulations are made until all of the available supply of water that is stored in the reservoirs or that flows into the reservoirs, after all senior water rights are fully satisfied, is completely utilized to meet the specified firm yield demand during the most severe drought period within the hydrologic record analyzed, which defines the drought of record.

For this combined firm yield analysis, monthly historical hydrologic and climatic conditions corresponding to the actual 1940-2009 sequence of events are considered. For lakes Buchanan and Travis, the drought of record that determines the combined firm yield value occurs during what is often referred to as the "drought of the 1950s." Based on the WAM simulations, this drought period extends from June of 1946 when both reservoirs are full, to August of 1952 when they are essentially empty and began to refill, and then through June of 1957 when they are both refilled again to their full level, a total drought duration of 133 months, or 11.1 years. This critical drought period is evident on the time-series graph presented in Figure 1 depicting the monthly combined storage in lakes Buchanan and Travis from the 1940-2009 firm yield WAM simulation. As shown, the combined water in storage in the reservoirs almost falls to zero during

this period (August 1952), which is the fundamental basis for the determination of the combined firm yield of the reservoir system. Corresponding graphs of the monthly storage in Lake Buchanan and in Lake Travis are presented in Figures 2 and 3, respectively.

The annual withdrawal amount that has been determined from the WAM simulations to be the combined firm yield value for the Buchanan-Travis reservoir system is 434,549 acre-feet per year as compared to the value of 445,266 acre-feet per year calculated in the original WMP, approximately a 2% reduction. This is the maximum amount of water that can be withdrawn from the two reservoirs every year during the critical drought period without causing the reservoirs to go dry. The reduction in combined firm yield is mainly due to sedimentation that has occurred since the firm yield calculations were performed for the original WMP. LCRA has conducted sediment surveys in the recent past utilizing the Texas Water Development Board's Hydrographic Survey program, and results from these surveys have been used to estimate 2010 sedimentation conditions in the reservoirs for this revision of the WMP.

### **3.0 ASSUMPTIONS**

Assumptions regarding how the Buchanan-Travis reservoir system is represented and operated in the WAM and the extent to which water from these reservoirs is used to meet specific demands can vary considerably depending on the purpose for which WAM simulations are being made. For purposes of the Buchanan-Travis combined firm yield calculation in support of this WMP, the specific assumptions utilized are outlined and described in the following sections. The particular version of the WAM for the Colorado River Basin with these specific combined firm yield assumptions incorporated is referred to as the CFY-WAM.

#### **3.1 General Assumptions**

- 3.1.1 The TCEQ's water availability model of the Colorado River Basin (Run 3) forms the basic structure for the CFY-WAM. This model is assumed to appropriately reflect water rights and hydrologic conditions in the basin so as to provide for meaningful and accurate simulations of water availability. The July 2010 version of the Texas A&M University "Water Rights Analysis Package" (WRAP) is the underlying program code used for all CFY-WAM simulations.
- 3.1.2 A "no-call" assumption<sup>3</sup> with respect to upper basin water rights has been incorporated into the CFY-WAM. This "no-call" assumption, in effect, makes all water rights upstream of the dams that form Ivie and Brownwood Reservoirs senior in priority to the Highland Lakes and other downstream water rights; however, the existing priorities of all of the water rights located upstream of these dams are maintained relative to each other, as are those for all of the water rights located downstream of these dams.

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<sup>3</sup> The "no-call" assumption in the WAM is an attempt to reflect the various agreements that LCRA has with upstream reservoir owners, i.e. Colorado River Municipal Water District, San Angelo Water Supply Corporation, and Brown County WID No. 1, and to better represent actual conditions with regard to the operation of existing water rights throughout the basin.

FIGURE 1 MONTHLY COMBINED STORAGE IN LAKES BUCHANAN AND TRAVIS FROM FIRM YIELD WAM SIMULATION

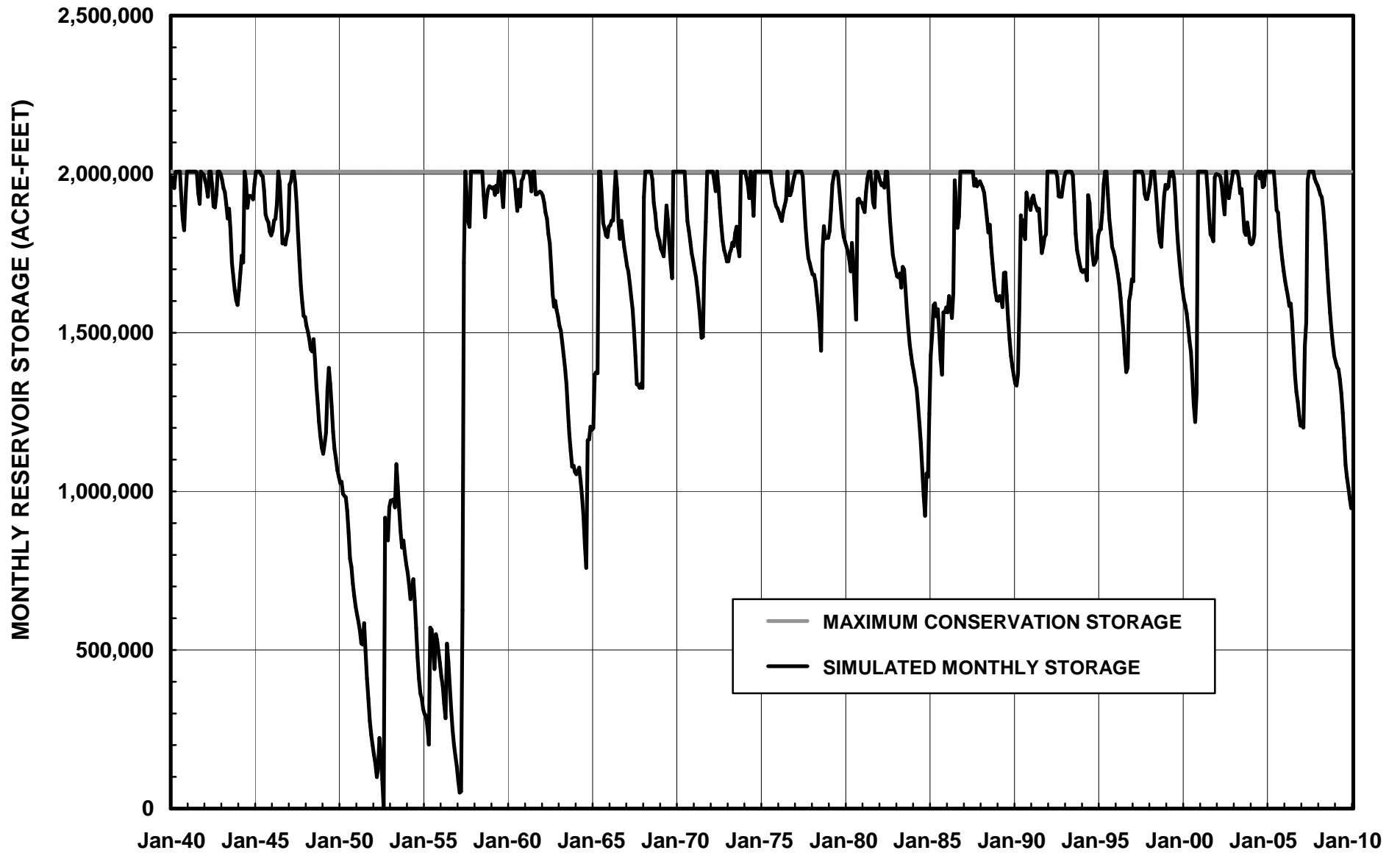


FIGURE 2 MONTHLY STORAGE IN LAKE BUCHANAN FROM FIRM YIELD WAM SIMULATION

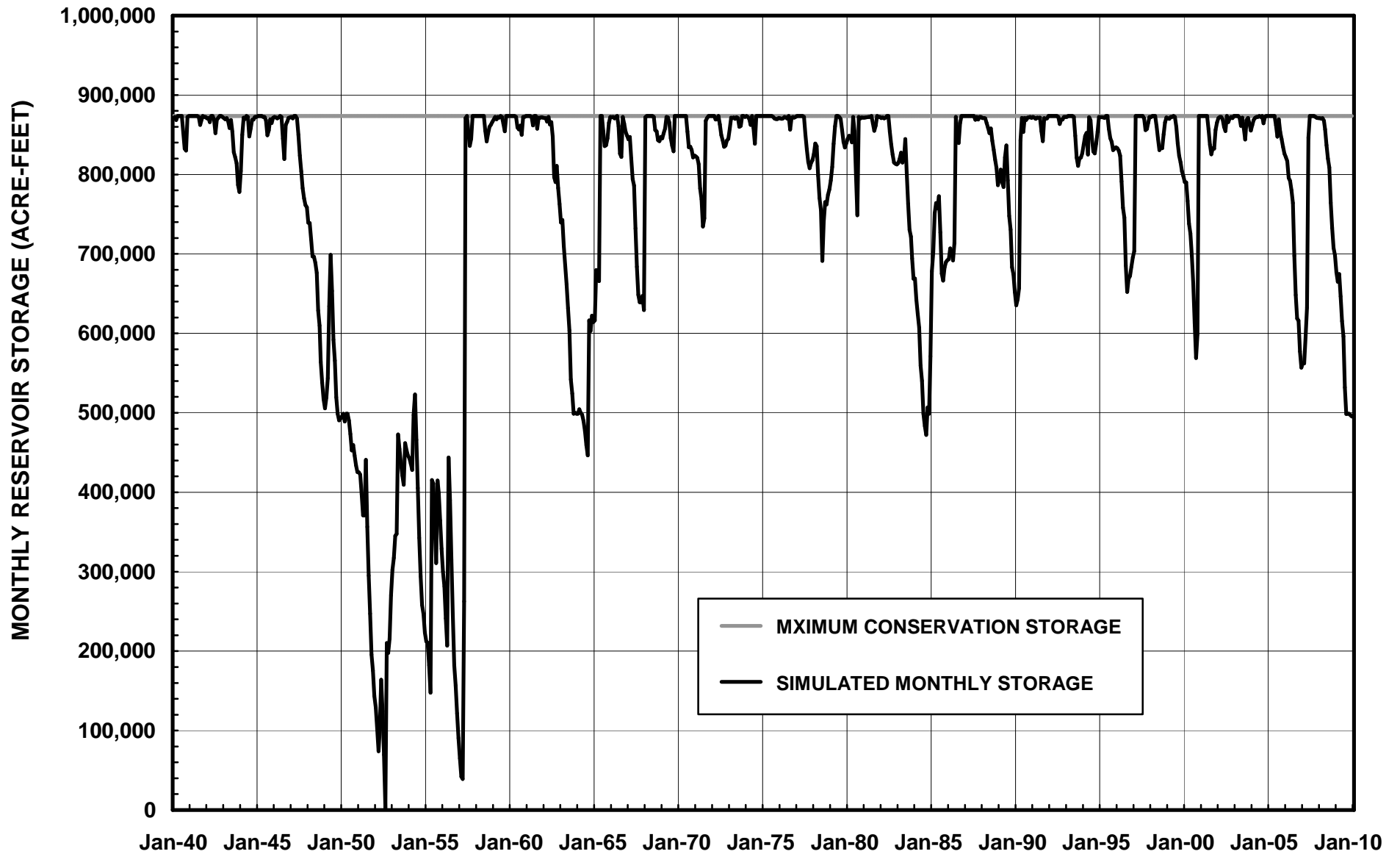
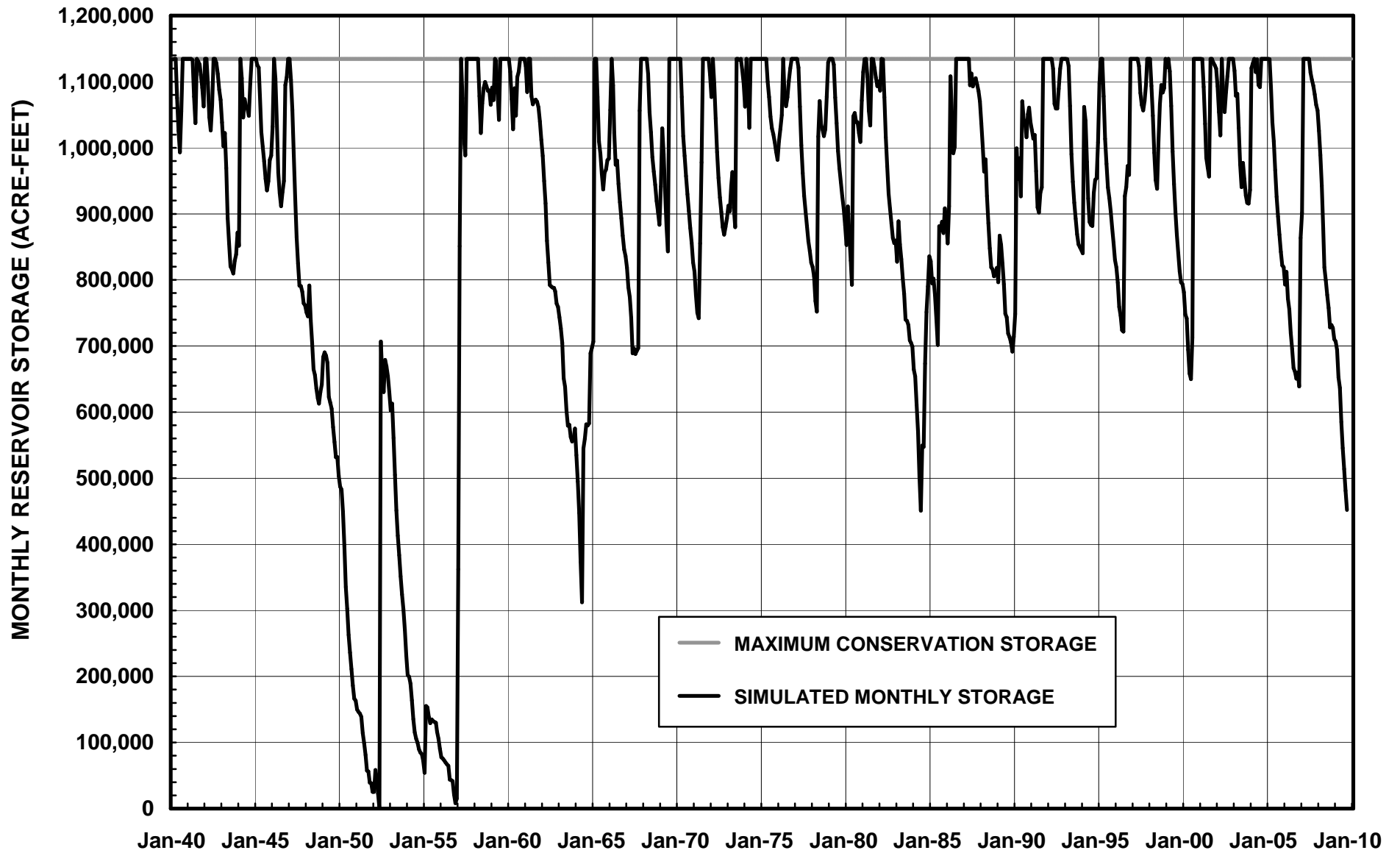


FIGURE 3 MONTHLY STORAGE IN LAKE TRAVIS FROM FIRM YIELD WAM SIMULATION



- 3.1.3 The 1940-1998 monthly naturalized flows<sup>4</sup> and net evaporation rates included in the TCEQ's Run 3 WAM for the Colorado River Basin have been extended through calendar year 2009, and this extended database was used in all simulations associated with the CFY-WAM. These data are considered to be representative of actual variations in hydrologic and climatic conditions sufficient to support meaningful and accurate simulations of water availability, including consideration of the extreme drought of the 1950s that typically limits the water supplies available for satisfying future water demands and needs.
- 3.1.4 Potential droughts worse than the historical drought of record are not simulated. As stated previously, the firm yield is based upon a repeat of the historic drought of record. As new hydrologic and climatic conditions are encountered, there is the potential that a new drought of record will be determined.
- 3.1.5 In the CFY-WAM, water demands for all surface water rights in the Colorado River Basin are set at their full authorized diversion amounts, and all reservoirs are specified at their authorized storage capacities, except for lakes Buchanan and Travis (See section 3.4.1-3 for more detail). The authorized demands and priority dates for the major downstream water rights that are senior in priority to the Highland Lakes are listed in Table 1. This table only reflects those senior water rights authorized to divert greater than 1500 acre-feet.

## **3.2 City of Austin Return Flows**

- 3.2.1 The use of surface water by the City of Austin either from diversions under Austin's municipal water rights or from releases from lakes Buchanan and Travis under contract with LCRA is assumed to generate treated wastewater effluent that is discharged as return flows back into the Colorado River downstream of Austin. In the CFY-WAM, these return flows are determined using procedures consistent with those employed by the Region K Water Planning Group involving the following calculations:
  - 1) At the end of each monthly time step during a CFY-WAM simulation, the total amount of Colorado River water used by the City of Austin to satisfy its municipal and industrial (M&I)<sup>5</sup> water demands is noted.

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<sup>4</sup> Naturalized flows provide the basic hydrologic inputs to the WAM, and they consist of complete records over the WAM simulation period of historical monthly flows at specific locations throughout the Colorado River Basin (usually at streamflow gaging stations) after adjustment for the effects of historical surface water use activities, including diversions, return flows, and reservoir storage and evaporation losses. For the CFY-WAM, the 1940-1998 naturalized flows were extracted from the TCEQ's existing WAM for the Colorado River Basin, and the naturalized flows for the 1999-2009 period were developed by LCRA using the same methodology applied in developing the original WAM for the Colorado River Basin.

<sup>5</sup> In the CFY-WAM, Austin's municipal and industrial demands are set at the total amount of annual diversions authorized under Austin's municipal water rights, Certificates of Adjudication 14-5471 and 14-5489, and these demands equal 291,703 acre-feet/year. These demands do not include any Austin water usage for power generation.

**TABLE 1**  
**DOWNSTREAM WATER RIGHTS SENIOR IN PRIORITY TO THE HIGHLAND LAKES**

<b>WATER RIGHT OWNER (Certificate of Adj. No.)</b>	<b>AUTHORIZED USES</b>	<b>AUTHORIZED DIVERSION (ac-ft/year)</b>	<b>PRIORITY DATE</b>
City of Austin (14-5471B)	Municipal Irrigation Municipal Industrial	250,000 150 22,403 24,000	6-30-1913 <sup>(a)</sup> 6-30-1913 <sup>(a)</sup> 6/27/1914 6/27/1914
Lakeside <sup>(b)</sup> (14-5475A)	Irrigation Irrigation & Municipal	52,500 <sup>(c)</sup> 55,000	1/4/1901 9/1/1907
Garwood <sup>(b)</sup> (14-5434C)	Municipal, Industrial, & Irrigation	133,000	11/1/1900
City of Corpus Christi (14-5434B)	Municipal, Industrial, & Irrigation	35,000	11/2/1900
Pierce Ranch <sup>(b)</sup> (14-5477D)	Municipal, Industrial, Irrigation, & Recreation	55,000	9/1/1907
Gulf Coast <sup>(b)</sup> (14-5476A)	Irrigation	228,570 <sup>(c)</sup>	12/1/1900
<b>TOTAL</b>	<b>All</b>	<b>857,598</b>	<b>- -</b>

(a) Any water right owned by LCRA with a priority date junior to November 15, 1900 is specifically subordinated as to priority to this right.

(b) Water right is owned by LCRA.

(c) Lakeside and Gulf Coast water rights have additional authorized diversions for irrigation of 78,750 and 33,930 acre-feet/year, respectively, with a junior priority date of November 1, 1987.

- 2) The corresponding quantity of Austin's treated wastewater effluent then is calculated by applying the appropriate monthly factor from the following list to Austin's total M&I demands. These factors were derived from Austin's actual river diversions and return flows as reported for the 2000-2005 period.

Jan	Feb	Mar	Apr	May	Jun
0.7873	0.8027	0.7994	0.6487	0.5509	0.5379
Jul	Aug	Sep	Oct	Nov	Dec
0.4597	0.4213	0.4821	0.5806	0.7215	0.7735

This calculation process results in an annual total of approximately 176,600 acre-feet/year of return flows that are discharged back into the Colorado River.

- 3) At the beginning of each monthly time step during the CFY-WAM simulation, the calculated amount of Austin's treated wastewater effluent from the previous time step is returned to the Colorado River at a location approximately four river miles downstream of the Highway 71/183 bridge in Austin (mouth of Walnut Creek), and these return flows are then available for use in priority order by all downstream water rights.
- 4) No direct or indirect reuse of Austin's treated wastewater effluent or return flows is represented in the CFY-WAM simulations. The City of Austin has not identified any indirect reuse projects in the 2011 Region K Plan through at least 2060. Austin's return flows are discharged to the river and made available for use by all downstream water users in accordance with the prior appropriation doctrine and consistent with the 2007 Settlement Agreement.

### **3.3 LCRA Irrigation Demands**

- 3.3.1 Water demands associated with the four downstream irrigation operations in the lower Colorado River Basin (Garwood, Lakeside, Pierce Ranch and Gulf Coast) are set at the full authorized diversion amounts stipulated in the existing LCRA downstream water rights at these locations. The same monthly distribution factors included in TCEQ's Run 3 WAM for each of the irrigation operations are used to distribute the annual authorized diversion amounts to monthly demands in the CFY-WAM. Irrigation demands for the different lower basin water rights are considered in priority order in the CFY-WAM simulation process.
- 3.3.2 Only diversions made under LCRA's downstream water rights are used to try to satisfy the lower basin irrigation demands.
- 3.3.3 No interruptible water (stored water) from lakes Buchanan and Travis is provided to supplement or backup the supplies available under LCRA's downstream water rights for satisfying the lower basin irrigation demands.
- 3.3.4 No return flows from the downstream irrigation operations are discharged back to the Colorado River.



### **3.4 Lakes Buchanan and Travis Storage and Releases**

- 3.4.1 The conservation storage capacities of all reservoirs in the Colorado River Basin that are represented in the WAM, except lakes Buchanan and Travis, are set at their full authorized storage amounts as stipulated in their respective water rights. The conservation storage capacities for Lakes Buchanan and Travis are set at their estimated 2010 conservation capacities based on recent sediment surveys.
- 3.4.2 The conservation storage capacity of Lake Buchanan at elevation 1020.0 feet above mean sea level (msl) is specified as 873,572 acre-feet. This maximum storage capacity is used in the WAM simulations for all months of the year.
- 3.4.3 The conservation storage capacity of Lake Travis at elevation 681.0 feet msl is specified as 1,134,456 acre-feet. This maximum storage capacity is used in the WAM simulations for all months of the year.
- 3.4.4 Direct diversions of water are made from lakes Buchanan and Travis to satisfy the demands of LCRA's contractual customers.
- 3.4.5 Stored water is released from lakes Buchanan and Travis to backup the following downstream water demands:
  - City of Austin's municipal and industrial demands (excluding power generation); and
  - South Texas Project demands for power generation per contract provisions.
- 3.4.6 No water is released from the reservoirs to account for conveyance losses along the Colorado River.
- 3.4.7 Stored water is released from Lake Buchanan to maintain the intervening Highland Lakes (Inks, LBJ, and Marble Falls) full at all times.
- 3.4.8 Procedures for diverting water from either Lake Buchanan or Lake Travis to meet LCRA customer demands utilize the reservoir system operating rules that are embedded in the basic WRAP program. At any time, the relative storage conditions of the two reservoirs determine from which reservoir diversions or releases are to be made, with the overall objective of using water from Lake Travis at a somewhat higher rate than from Lake Buchanan in order to minimize flood spills from Lake Travis when Lake Buchanan is not full and to ensure that water stored in Lake Travis is fully utilized before the last diversion or release is made from Lake Buchanan when and if the reservoir system becomes fully depleted. Procedures for making diversions or releases under the current reservoir operating rules in the CFY-WAM are as follows:
  - 1) An Upper Zone (Zone 1) and a Lower Zone (Zone 2) are defined in each reservoir using 500,000 acre-feet for Lake Buchanan and 600,000 acre-feet for Lake Travis as the zone delineators.
  - 2) When the storage in one reservoir is in Zone 1 (Upper Zone) and the storage in the other reservoir is in Zone 2 (Lower Zone), diversions or releases to meet demands are made from the reservoir with storage in Zone 1 (i.e., from

the reservoir that contains more water in storage relative to its conservation storage capacity).

- 3) When both reservoirs are in the same storage zone, a quantity called the “zone storage factor” is calculated for each reservoir that is equal to the percent the zone is full. For example, if both reservoirs are in Zone 1 (Upper Zone) and Lake Travis contains 800,000 acre-feet of water, then the zone storage factor for Lake Travis would be equal to 200,000 (800,000 – 600,000) divided by the volume of Zone 1 in Lake Travis (equal to the full conservation storage capacity minus 600,000).
- 4) When both reservoirs are in Zone 1 (Upper Zone), the zone storage factor for Lake Travis is multiplied by 2, and if this quantity is greater than or equal to the zone storage factor for Lake Buchanan, diversions or releases are made from Lake Travis. If this quantity is less than the zone storage factor for Lake Buchanan, then diversions or releases are made from Lake Buchanan.
- 5) When both reservoirs are in Zone 2 (Lower Zone), the zone storage factor for Lake Travis is multiplied by 3, and if this quantity is greater than or equal to the zone storage factor for Lake Buchanan, diversions or releases are made from Lake Travis. If this quantity is less than the zone storage factor for Lake Buchanan, then diversions or releases are made from Lake Buchanan.

### **3.5 Environmental Instream Flow Requirements**

- 3.5.1 No instream flow requirements for environmental protection are imposed on any existing LCRA water rights in the CFY-WAM, and, consequently, no water is released from or passed through the Highland Lakes to support instream flow requirements at any location downstream along the Colorado River.

### **3.6 Environmental Matagorda Bay Inflow Criteria**

- 3.6.1 No bay and estuary inflow requirements for environmental protection are imposed on any existing LCRA water rights in the CFY-WAM, and, consequently, no water is released from or passed through the Highland Lakes to supplement the Colorado River inflows to Matagorda Bay.

### **3.7 South Texas Project**

- 3.7.1 The consumptive demand for the South Texas Project (STP) is set equal to the full authorized consumptive demand stated in the jointly held LCRA/STP water right (80,125 acre-feet/year representing four generating units).
- 3.7.2 The current Water Delivery Plan (WDP) for providing backup water to STP, which was adopted as part of the 2006 Settlement Agreement between LCRA and STP, is implemented in the CFY-WAM. As structured, this WDP stipulates that LCRA shall initiate staged deliveries of water to STP from LCRA’s available sources upstream of the Bay City Dam when the water surface elevation of STP’s main cooling reservoir (MCR) falls below 35 feet MSL, and shall continue such

deliveries to assist with maintaining the level of the MCR above a minimum elevation of 27 feet MSL.

- 3.7.3 The WDP does not specifically state how the water deliveries are to be staged with regard to either timing or the quantities to be delivered; it only requires that they commence when the level of the MCR falls below elevation 35 feet MSL. For purposes of the CFY-WAM, the operating procedures for delivery of water is assumed to be consistent with the previous water delivery plan as described in the technical memorandum, Assumptions Underlying LCRA 2010 WMP Baseline WAMs, found in Appendix A, Technical Paper A-3.
- 3.7.4 The total backup supply from the Highland Lakes for STP is limited to a rolling 5-year average of 40,000 acre-feet/year.
- 3.7.5 The CFY-WAM assumes that STP will divert under Certificate of Adjudication 14-5437, whenever the streamflow exceeds the parameters in the certificate without regard to any operational preferences related to salinity or conductivity.

**TECHNICAL PAPER A-6**  
**PROPOSED METHODOLOGY FOR IDENTIFYING A DROUGHT**  
**POTENTIALLY WORSE THAN THE DROUGHT OF RECORD**  
**January 2012**

**1.0 Background**

The LCRA Water Management Plan, as approved by the Texas Commission on Environmental Quality (TCEQ), provides for special curtailment policies and procedures during drought conditions that are potentially worse than the drought of record. The “Drought of Record<sup>1</sup>” is a criterion used by the State of Texas for the permitting and planning of firm surface water supplies. However, it is recognized that droughts worse than this one have occurred in the past (based on analysis of tree ring data in other areas of the state) and will occur again in the future. Recognizing this possibility, the method outlined in this memorandum is meant to establish when a drought worse than the Drought of Record may be underway. This will allow additional water supply management strategies to be implemented in a timely manner.

Droughts can be characterized in many ways. For purposes of this document a hydrologic drought (a drought that affects water supplies) is implied throughout. A drought can vary in terms of both duration and intensity. Severe droughts may be more intense but have shorter durations or have longer durations and less intensity. This memorandum presents a methodology to identify droughts that are potentially worse than the Drought of Record in terms of the combined impacts of duration and intensity, to allow LCRA to take prudent management actions in a timely manner.

An important element of developing a comprehensive methodology is to be able to identify a drought potentially worse than the Drought of Record while the drought is still in progress. This allows appropriate and timely measures to be implemented to help mitigate potential shortages during such an event. Timely action under a drought potentially worse than the Drought of Record can lessen the need for more restrictive demand reductions and the resulting consequences of more severe water supply shortages. In general, the earlier demand reduction measures can be taken in a drought, the less likely it becomes that more restrictive measures will be needed later in the drought cycle. Unfortunately, it can only be known for sure that a drought is worse than the Drought of Record either after the drought is over or after inflow conditions have been so low for so long that the combined firm yield could not have been sustained. It could then be too late to take demand reduction measures to avert a severe shortage and the potential to run out of water. Similarly, declaring a drought worse than the Drought of Record too early can lead to false alarms. False alarms can be costly to customers and stakeholders while eroding the effectiveness of declarations. The method outlined below has been developed to strike a balance between early detection and minimizing false alarms.

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<sup>1</sup> Drought of record--The historic period of record for a watershed in which the lowest flows were known to have occurred based on naturalized streamflow. 30 TAC §297.1(19)

Precautionary actions taken earlier in a drought provide for greater water supply security than the Drought of Record criteria alone. Procedures have been developed for identifying a drought potentially worse than the Drought of Record for the water supply reservoirs in the Highland Lakes (lakes Buchanan and Travis). These procedures should continue to be updated as additional data and methods become available. This document sets forth the current understanding of best management practices for anticipating drought conditions potentially worse than the Drought of Record and the technical basis for declaring a drought potentially worse than Drought of Record.

## **2.0 Criteria for Declaration of a Drought Worse than Drought of Record**

The proposed criteria should include the following:

- drought duration of more than 24 months since the start of the drought; and
- drought intensity greater than that of the Drought of Record as measured by captured inflows into the Highland Lakes; and
- combined storage content of lakes Buchanan and Travis of 600,000 acre-feet or less.

Alternately, if a drought in progress has exceeded 120 months in duration, and the content criteria is also met, a declaration of a Drought Worse than Drought of Record should be made regardless of the status of the intensity criteria.

The specific details of the computations and comparison are the subject of this memorandum. The method has been implemented in a Microsoft Excel spreadsheet for ease of use.

### **2.1 Duration Criterion**

To meet the duration criteria, the duration of the drought must be at least 24 months since lakes Buchanan and Travis were both full. A hydrologic drought could be in progress at any time that combined conservation storage of lakes Buchanan and Travis are less than full. For the purposes of this method, full is defined as when either of the following criteria is met:

- a) Combined storage in lakes Buchanan and Travis is at or above 98 percent of the combined managed conservation storage. The managed combined content is no more than 2,011,000 acre-feet but may be lower depending upon operational guidelines which may change seasonally or for special purposes. When Lake Buchanan is limited to not exceeding elevation 1018 ft-msl, the managed combined conservation storage is 1,967,000 acre-feet; or
- b) Lakes Travis and Buchanan have each been at their respective managed conservation storage maximum capacity within 30 days of each other.

### **2.2 Inflow Criterion**

Two inflow data sets are used in the inflow criterion computation. The first is the reference inflow set and the other is the LCRA inflow data.

The reference inflow data comes from the monthly Water Availability Model (WAM) Water Rights Analysis Program (WRAP) firm yield simulation. Details of this simulation are further described in Technical Paper A-5, *Development of the Combined Firm Yield of Lakes Buchanan and Travis* found in the Appendix A. For the reference data set, the Drought of Record period starts in August 1947 (month 1) and ends May 1957 (month 118). It can also be stated that July 1947 preceded the drought (month 0) and the drought was over in June of 1957, or 119 months later. The specific drought months are unique to the simulation and the assumptions of the firm yield simulation. The reference inflow data set represents regulated flows contributing to lakes Buchanan and Travis through the historical gaged period of 1940 to 2009. Flows are determined based on full use of adjudicated water rights in priority order.

The LCRA inflow data set is compared to the reference inflow set. The LCRA inflow data is computed from measurements at principle USGS and LCRA jointly monitored gages above lakes Buchanan and Travis on the Colorado River, Llano River, Pedernales River, and Sandy Creek according to LCRA methods.<sup>2</sup> Measurements may be preliminary, provisional, or published and are subject to revision until published. Measurements reflect upstream diversions made by upstream water right holders. Historically, LCRA inflows were higher than the reference inflow data set because upstream users were diverting lower quantities and upstream reservoirs had yet to be constructed. However in the more recent years, the upstream uses have grown and the two data sets converge as seen in Figure 1.

An inflow envelope curve has been developed for the period of the Drought of Record using the reference inflow data set. The envelope curve generally encapsulates the cumulative inflows during the critical periods of the Drought of Record as shown in Figure 2. The envelope curve consists of a uniform slope of 56,798 ac-ft/month for the first 62 months and then the slope changes to 73,241 ac-ft/month for the remainder of the drought.

If the cumulative inflow since the start of a drought in progress is more than the envelope curve value for the same duration of drought, the intensity criterion is not met. Conversely, if the cumulative inflow is below the envelope line, then criterion is met and the drought is more intense than the Drought of Record.

This simplified inflow method replaces prior deficit methods, which proved to be confusing to stakeholders and the public alike. Nonetheless, it is functionally equivalent to prior methods used to identify droughts potentially worse than the Drought of Record in intensity.

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<sup>2</sup> LCRA River Operations Center, Procedures Manual, Monthly Highland Lakes Water Balance, Section 0510.

Figure 1 - Reference and LCRA Inflow Data Sets

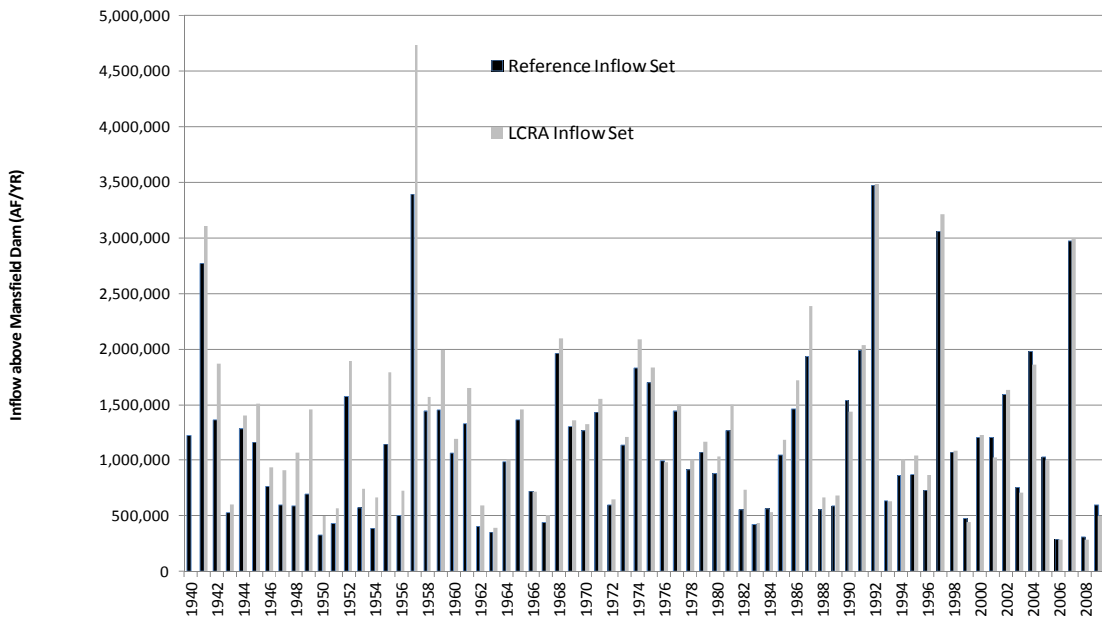
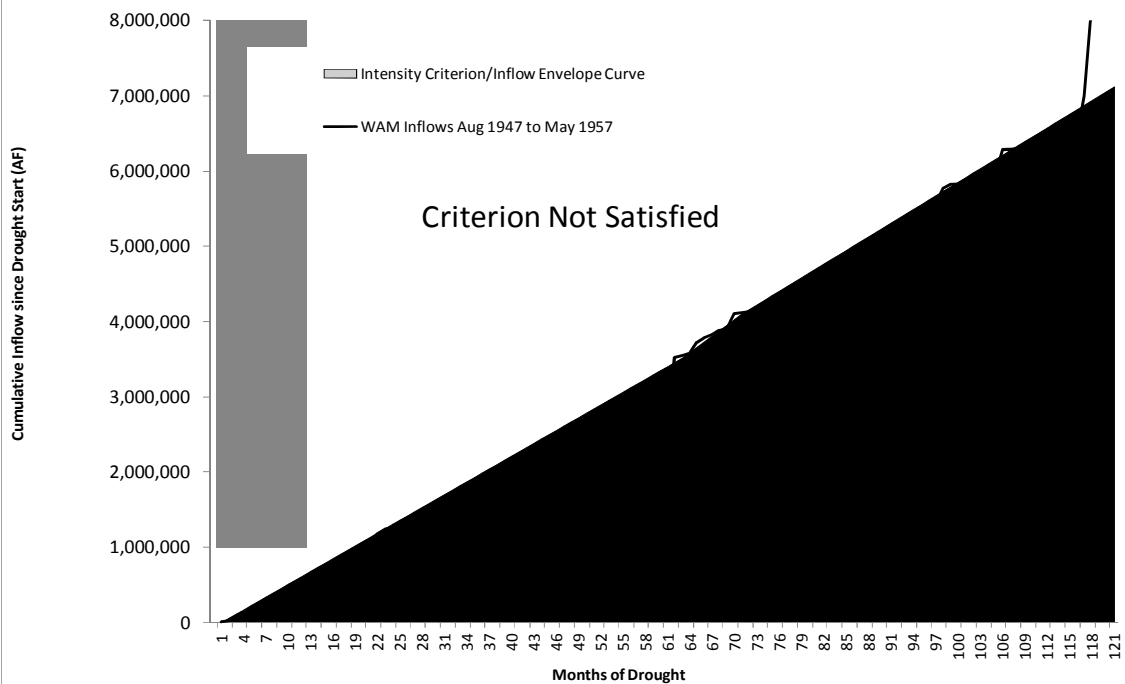


Figure 2 - Intensity Criterion Inflow Envelope Curve



## **2.3 Content Criterion**

The content criterion for a drought potentially worse than the Drought of Record is that the combined storage of lakes Buchanan and Travis is less than 600,000 acre-feet. This level of combined storage has never been previously observed<sup>3</sup> and provides a practical restriction to reduce false alarms.

## **3.0 Declaration and Cancellation**

For a declaration of drought potentially worse than the Drought of Record, all three of the intensity, duration, and content criteria should be simultaneously satisfied. Alternately, if a drought in progress has exceeded 120 months in duration, and combined storage is below the 600,000 acre-feet criterion, a declaration of a drought potentially worse than the Drought of Record should also be made regardless of the status of the intensity criterion.

Criterion for the cancellation of a declaration of drought potentially worse than Drought of Record may be based upon an increase in combined storage to a level of 900,000 acre-feet or other cancellation criteria as determined by the LCRA Board.

## **Analysis of Historical Droughts**

Other droughts during the period of gauged record have been shorter in duration than the Drought of Record. Inflows for these shorter duration droughts were analyzed according to this procedure. Cumulative inflows of the selected historical droughts of shorter duration are shown in Figure 3. This figure shows that, for some of these droughts of shorter duration, cumulative inflows early in the drought cycle satisfied the intensity criterion but the duration of these droughts was shorter or they did not achieve the lake content criterion necessary for declaration of a drought potentially worse than Drought of Record.

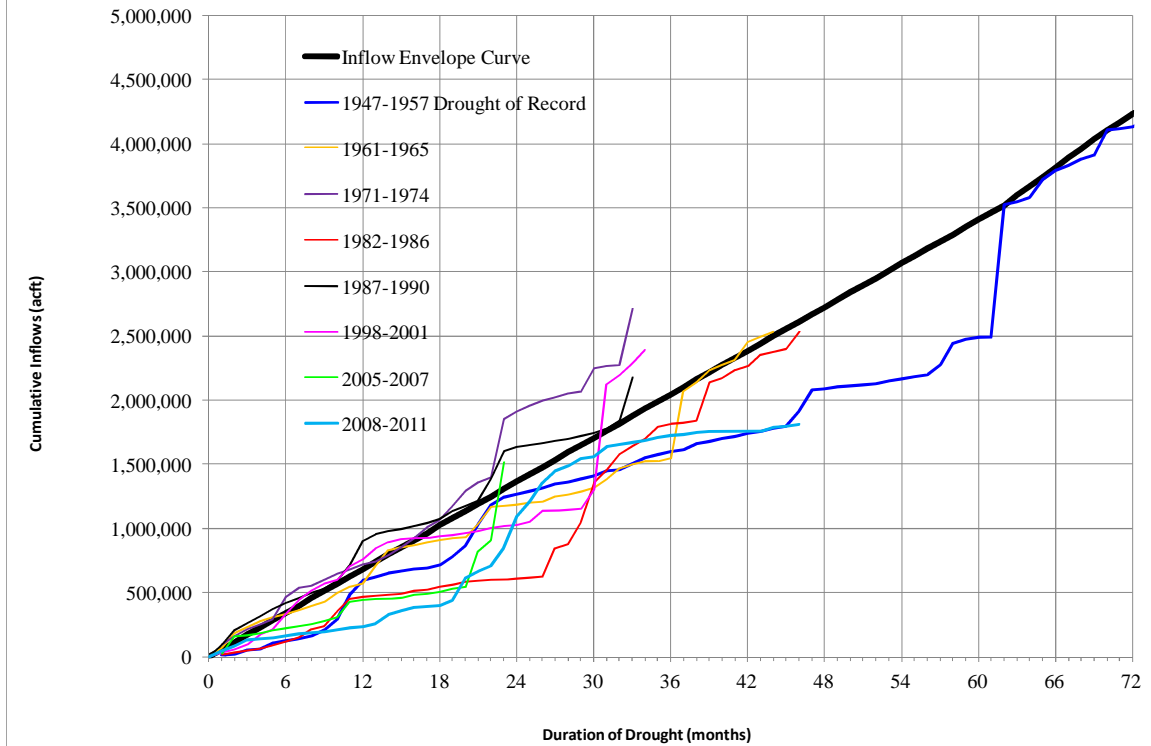
In summary, none of these other historical droughts would have triggered a declaration of a drought potentially worse than Drought of Record based on this procedure and current criteria. A summary of the droughts and respective criteria are shown in Table 1.

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<sup>3</sup> The lowest recorded combined storage of 621,221 ac-ft was observed in September 9, 1952.



Figure 3 - Analysis of Historical Droughts



**Table 1. Summary of Selected Historical Droughts Compared to Drought Potentially Worse Than Drought of Record Declaration Criteria**

Years of Drought	Simultaneous Criteria			Eligible for Declaration
	Inflows < DOR	Duration ≥ 24 months	Storage < 600,000 acft	
1961-1965	Yes	Yes	No	No
1971-1974	No	No	No	No
1982-1986	Yes	Yes	No	No
1987-1990	No	Yes	No	No
1998-2001	Yes	Yes	No	No
2005-2007	No	No	No	No
2008-2011	Yes	Yes	No	No

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## **Appendix B-1**

### **Corps of Engineers Flood Control Regulations Governing Releases from Mansfield Dam**

## DEPARTMENT OF DEFENSE

Corps of Engineers, Department of the Army

## 33 CFR Part 208

Flood Control Regulations; Marshall Ford Dam and Reservoir, Colorado River, Tex.

AGENCY: U.S. Army Corps of Engineers, DoD.

ACTION: Final rule.

**SUMMARY:** On 8 April 1978 interim regulations were published in the Federal Register (41 FR 15005) to permit time for completion of detailed studies. Upon completion of a hydrologic computer model of the Colorado River Basin, the operation of thirteen of the major lakes of the basin were simulated using the historical streamflow records for the forty-five year period from 1 January 1930 through 31 December 1974. From this simulation study, the results of 14 different regulation plans for Marshall Ford Dam and Reservoir were presented by the District Engineer at a public meeting held in Austin, Texas, on 5 January 1978. As a result of comments received at that meeting plus subsequent workshops and technical meetings, additional regulation plans were analyzed, resulting in the development and presentation of the revised plan at a

second public meeting in Austin, Texas, on 19 December 1978. The revised plan will result in a significant increase in overall flood protection without a significant decrease in the generation of hydroelectric energy. The revised regulation plan also meets current downstream water supply demands, will lower the 1% floodplain elevations both in the reservoir and downstream through Austin area, and will not have a significant adverse impact on the environment. This revised regulation plan is jointly supported by the Corps of Engineers, the Bureau of Reclamation, and the Lower Colorado River Authority.

**EFFECTIVE DATE:** This revision of Section 208.19 becomes effective on May 29, 1979.

**ADDRESSES:** HQDA (DAEN-CWE-HY) Washington, D.C. 20314.

**FOR FURTHER INFORMATION CONTACT:** Mr. Edgar P. Story, Engineering Division, Civil Works Directorate, Office of the Chief of Engineers, Washington, D.C. 20314 (202-693-7330).

**Note.**—The Chief of Engineers has determined that this rule does not contain a major proposal requiring preparation of an Inflation Impact Statement under Executive Order 11821 and OMB (Circular A-107) (Statutory Authority Pub. L. 90-483).

**SUPPLEMENTARY INFORMATION:** Recognizing that increased urban development has occurred both within the reservoir area and downstream of the project, major factors considered in the derivation of the proposed plan included:

- (a) The importance of hydroelectric power generation.
- (b) The seasonal nature of floods in the Colorado River Basin.
- (c) The ability to meet downstream water demands.
- (d) An equitable balance of flood damage risks between upstream and downstream property owners.
- (e) A preliminary environmental impact assessment of the flood regulation plan.
- (f) The current ability to adequately forecast floods consistent with austere funding limitations and the current state-of-the-art technical developments.
- (g) A coincident probability analysis of the 1% flood.
- (h) The public input received in response to the public meeting and workshops.

The overall changes from the 1978 interim plan of regulation are as follows:

- (a) Release rates shall continue to be 3,000 c.f.s. when the pool elevation is forecast to be between elevation 681 and 683 feet, m.s.l. and 5,000 c.f.s. when

the pool elevation is forecast to be higher than elevation 683 feet, m.s.l., but less than 685 feet, m.s.l. When the pool elevation is forecast to be between 685 and 691 feet, m.s.l. a seasonal plan of regulation shall be followed: During the months of May, June, September, and October, the coordinated release rate shall be increased to the maximum amount which, when combined with local flows below the dam, does not exceed 30,000 c.f.s. (20.5 feet) at the Austin USGS gage, 45,000 c.f.s. (25.1 feet) at the Bastrop USGS gage, or 50,000 c.f.s. (25.5 feet) at the Columbus USGS gage. During the months of January through April, July, August, November, and December the release rate shall be 5,000 c.f.s.

(b) If conditions are such that the reservoir elevation is forecast to exceed elevation 710 feet, m.s.l. but not 714 (top of flood control pool) feet, m.s.l., the coordinated releases, when combined with downstream local flows, will not exceed the downstream control stage of 24.8 feet (50,000 c.f.s.) at the USGS gaging station at Austin.

(c) If the reservoir elevation is forecast to exceed elevation 714 feet, m.s.l. but not 722 feet, m.s.l. the rate of release shall not exceed the associated peak flood inflows into the reservoir or 90,000 c.f.s., whichever is the lesser. As the actual lake level exceeds elevation 714 feet, m.s.l. the Bureau of Reclamation assumes responsibility for determining releases to protect the safety of the structure.

**Use of revised regulations prior to promulgation:** The revised regulation will be used in the event of a flood in the Colorado River Basin which requires flood control regulation at Marshall Ford Dam, in lieu of the interim regulation plan of 1 April 1978.

**Effective date:** This revision of Section 208.19 becomes effective on May 29, 1979.

Dated: April 17, 1979.

Charles L. McGinnis,  
Major General, USA, Director of Civil Works.

Accordingly, 33 CFR 208 is amended by revising Section 208.19 as set forth below.

[Page 125-128]

TITLE 33--NAVIGATION AND NAVIGABLE WATERS

CHAPTER II--CORPS OF ENGINEERS, DEPARTMENT OF THE ARMY, DEPARTMENT OF DEFENSE  
PART 208\_FLOOD CONTROL REGULATIONS--Table of Contents

Sec. 208.19 Marshall Ford Dam and Reservoir (Mansfield Dam and Lake Travis), Colorado River, Tex.

The Secretary of the Interior, through his agent, the Lower Colorado River Authority (LCRA) shall operate the Marshall Ford Dam and Reservoir in the interest of flood control as follows:

(a) Water Control Plan--

(1) General objectives. The objectives of the Marshall Ford Reservoir (Lake Travis) are the improvement of navigation, flood control, stream regulation, generation of power, irrigation, water supply, and recreation uses.

(2) Overall plan for water control. Within the Colorado River Basin, four Federal projects provide flood control protection: Twin Buttes, O. C. Fisher, Hords Creek, Marshall Ford Reservoir. The considerable distance (328 river miles) and large intervening area (19,990 square miles) separating Marshall Ford Reservoir and the three upper basin flood-control projects prevent realizing any significant benefits from coordinating releases to control the inflow into Marshall Ford. Marshall Ford Reservoir is the fifth project in a tandem of six lakes operated and controlled by the Lower Colorado River Authority for the generation of hydroelectric power. These six projects in downstream order are: Lake Buchanan, Lake Inks, Lake Lyndon B. Johnson (Alvin Wirtz Dam), Lake Marble Falls (Max Starcke Dam), Marshall Ford Reservoir (Lake Travis and Mansfield Dam) and Lake Austin (Tom Miller Dam). The releases from each of the six projects are closely coordinated by the LCRA System Operation Control Center. Three of the projects (Lake Inks, Lake Marble Falls, and Lake Austin) are run-of-the-river projects. The capability of the four upstream lakes to control the inflow of flood water into Marshall Ford depends on their antecedent lake elevations. The majority of inflows to Marshall Ford are comprised of the mainstream flows of the Colorado River, the tributary flows of the Llano River (entering the Colorado River between Lakes Inks and Lyndon B. Johnson) and the unregulated tributary flows of the Pedernales River (entering between Lake Marble Falls and Marshall Ford Reservoir). During flood conditions, the following upstream U.S. Geological Survey gaging stations are used as indicators of the magnitude of the inflows to Marshall Ford Reservoir:

- (i) Colorado River near San Saba (08147000).
- (ii) Pedernales River near Johnson City (08153500).
- (iii) Llano River at Llano (08151500).

(3) Standing instructions to dam tender. During normal conditions, the dam tender will regulate the project in accordance with instructions received from the LCRA System Operator. During flood conditions, when the Marshall Ford Reservoir level is within the flood control zone, the LCRA System Operator will regulate the project in accordance with instructions received from the Corps of Engineers. In the event of a communication outage, the LCRA

System Operator will rely on the Emergency Release Schedule, to make changes in the rate of releases from the lake.

(4) Flood control regulation--

(i) General. At all times, releases shall be coordinated such that the Colorado River, Texas, will be controlled when possible, to remain below control stages at downstream official U.S. Geological Survey (USGS) gaging stations; except that no curtailment of normal hydroelectric turbine releases shall result thereby at any time. The USGS river stations and their control stages are as follows:

Key Downstream Control Points		
Station	Control stage (feet)	Equivalent cubic feet per second (c.f.s.)
Austin (08158000)	20.5	30,000
	<sup>1</sup> 24.8	<sup>1</sup> 50,000
Bastrop (08159200)	25.1	45,000
	<sup>1</sup> 26.7	<sup>1</sup> 50,000
Columbus (08161000)	25.5	50,000

<sup>1</sup>Control stage when elevation 710 is forecast to be exceeded.

Forecasted reservoir inflows and the upstream USGS gaging stations Pedernales River near Johnson City (08153500), Llano River at Llano (08151500), and Colorado River near San Saba (08147000) will be considered when scheduling flood releases.

(ii) Flood control release schedule. Marshall Ford will be regulated to reduce flooding on the Colorado River below the dam. This plan of regulation will govern flood control releases from Marshall Ford Dam as follows:

(A) Elevation 681-683. If the reservoir level is forecast to rise above elevation 681 feet, m.s.l. (top of conservation pool) but not to exceed elevation 683 feet, m.s.l., the releases shall be increased to 3,000 c.f.s. and maintained until the reservoir level recedes to elevation 681 feet, m.s.l. These release rates may need to be reduced due to excessive downstream runoff to prevent exceeding the control stages specified in paragraph (a)(4)(i) of this section.

(B) Elevation 683-685. If the reservoir elevation is forecast to rise above elevation 683 feet, m.s.l. but not to exceed elevation 685 the releases shall be increased to 5,000 c.f.s. and maintained until the reservoir level recedes below 683 feet, m.s.l. These release rates may need to be reduced due to excessive downstream runoff to prevent exceeding the control stages specified in paragraph (a)(4)(i) of this section.

(C) Elevation 685-691. Seasonal. (1) During the months of January through April, July through August, and November through December: If the reservoir elevation is forecast to rise above elevation 685 feet,

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m.s.l. but not to exceed elevation 691, the releases shall be increased to 5,000 c.f.s. and maintained until the reservoir level recedes below 683 feet, m.s.l. These release rates may need to be reduced due to excessive downstream runoff to prevent exceeding the control stages specified in paragraph (a)(4)(i) of this section.

(2) During the months of May, June, September, and October: Should the reservoir elevation be forecast to exceed 685 feet, m.s.l. but not to exceed elevation 691 feet, m.s.l.: Releases will be made at 30,000 c.f.s. from the project or at a rate such that, when combined with local inflows below the dam, will equal but not exceed downstream control stages on the Colorado River as specified in paragraph (a)(4)(i) of this section. These release rates will be maintained until the reservoir level falls below elevation 685 feet, m.s.l.

(D) Elevation 691-710. Should the reservoir elevation be forecast to exceed 691 feet, m.s.l. (the top of the joint use pool) but not to exceed elevation 710 feet, m.s.l.: Releases will be made at 30,000 c.f.s. from the project or at a rate such that, when combined with local inflows below the dam, will equal but not exceed downstream control stages on the Colorado River as specified in paragraph (a)(4)(i) of this section. These release rates will be so controlled until the reservoir level falls below elevation 691 feet, m.s.l.

(E) Elevation 710-714. If the reservoir level is forecast to exceed 710 feet, m.s.l. but not to exceed elevation 714 feet, m.s.l.: Releases will be made at 50,000 c.f.s. from the project or at a rate such that, when combined with local inflows below the dam, will equal but not exceed the downstream control stages on the Colorado River as specified in paragraph (a)(4)(i) of this section. These release rates will be maintained until the reservoir level falls below elevation 710 feet, m.s.l.

(F) Elevation 714-722. If the reservoir level is forecast to exceed 714 feet, m.s.l. but not to exceed 722 feet, m.s.l.: Releases will be made at 90,000 c.f.s. from the project. Releases shall not exceed the associated peak flood reservoir inflow.

(G) Elevation 722 and above. If the reservoir level is forecast to exceed elevation 722 feet, m.s.l., the Bureau of Reclamation will schedule releases as required for the safety of the structure.

(iii) Normal flood control regulation schedule. The following table, Flood Control Regulation Schedule, summarizes the flood control releases schedule for given reservoir levels and river conditions:

**Marshall Ford Dam and Reservoir Normal Flood Control Regulation Schedule**

Condition	Reservoir level	Flood control release	Control points
Pool Rising	Forecast 681 - 683 <sup>1</sup>	3,000 c.f.s.	30,000 c.f.s. (20.5 ft.) at Austin. 45,000 c.f.s. (25.1 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus.
Pool Rising	Forecast 683 - 685	5,000 c.f.s.	30,000 c.f.s. (20.5 ft.) at Austin. 45,000 c.f.s. (25.1 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus.
Pool Rising	Forecast 685 - 691: (a) During January, February, March, April, July, August, November, December (b) During May, June, September, October.	5,000 c.f.s.  30,000 c.f.s.	30,000 c.f.s. (20.5 ft.) at Austin. 45,000 c.f.s. (25.1 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus. 30,000 c.f.s. (20.5 ft.) at Austin. 45,000 c.f.s. (25.1 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus.
Pool Rising	Forecast 691 - 710	30,000 c.f.s.	30,000 c.f.s. (20.5 ft.) at Austin. 45,000 c.f.s. (25.1 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus.
Pool Rising	Forecast 710 - 714	50,000 c.f.s.	50,000 c.f.s. (20.5 ft.) at Austin. 50,000 c.f.s. (25.1 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus.
Pool Rising	Forecast 714 - 722 <sup>2</sup>	90,000 c.f.s.	No Controls
Pool Rising	Forecast above 722	The Bureau of Reclamation will specify the release for safety of the structure.	
Pool Falling	Above 722	The Bureau of Reclamation will specify the release for safety of the structure.	
Pool Falling	Forecast 714 - 722 <sup>2</sup>	90,000 c.f.s.	No Controls
Pool Falling	714 - 710	50,000 c.f.s.	50,000 c.f.s. (20.5 ft.) at Austin. 50,000 c.f.s. (25.1 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus.
Pool Falling	710 - 691	30,000 c.f.s.	30,000 c.f.s. (20.5 ft.) at Austin. 45,000 c.f.s. (25.1 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus.
Pool Falling	691 - 685: (a) During May, June, September, October.  (b) During January, February, March, April, July, August, November, December	30,000 c.f.s.  5,000 c.f.s.	30,000 c.f.s. (20.5 ft.) at Austin. 45,000 c.f.s. (25.1 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus. 30,000 c.f.s. (20.5 ft.) at Austin. 45,000 c.f.s. (25.1 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus.
Pool Falling	685 - 683	5,000 c.f.s.	30,000 c.f.s. (20.5 ft.) at Austin. 45,000 c.f.s. (25.1 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus.
Pool Falling	683 - 681	3,000 c.f.s.	30,000 c.f.s. (20.5 ft.) at Austin. 45,000 c.f.s. (25.1 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus.

<sup>1</sup> During flood conditions, when the reservoir level is below elevation 681 ft., m.s.l., the Corps of Engineers will provide recommendations to the Lower Colorado River Authority on flood control releases.

<sup>2</sup> Releases shall not exceed the associated peak flood reservoir inflow.

Note: No curtailment of normal hydroelectric turbine releases shall be required due to flood control operations.

(5) Deviation from normal regulation. (i) There are occasions when it is necessary or desirable to deviate from the water control plan for short periods of time as indicated in the following paragraphs:

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(A) The water control plan is subject to temporary modification by the Corps of Engineers, if found necessary in time of emergency. Requests for and action on such modifications may be made by the fastest means of communication available. The action taken shall be confirmed in writing the same day to the project owner and shall include justification for the action.

(B) The project owner may temporarily deviate from the water control plan in the event an immediate short-term departure is deemed necessary for emergency reasons to protect the safety of the dam, or to avoid serious hazards. Such actions shall be immediately reported by the fastest means of communication available. Actions shall be confirmed in writing the same day to the Corps of Engineers and shall include justification for the action. Continuation of the deviation will require the express approval of the Chief of Engineers, or his duly authorized representative.

(C) Advance approval of the Chief of Engineers, or this duly authorized representative, is required prior to any deviation from the plan of regulation prescribed or approved by the Corps of Engineers in the interest of flood control and/or navigation, except in emergency situations provided for in paragraph (a)(5)(i)(B) of this section. When conditions appear to warrant a prolonged deviation from the approved plan, the project owner and the Corps of Engineers will jointly investigate and evaluate the proposed deviation to insure that the overall integrity of the plan would not be unduly compromised. Approval of prolonged deviations will not be granted unless such investigations and evaluations have been conducted to the extent deemed necessary by the Chief of Engineers, or his designated representative, to fully substantiate the deviations.

(ii) The Fort Worth District Corps of Engineers will serve as the LCRA contact point for any deviation from or modification of the water control plan. The communication network will be described in the Water Control Manual. The Fort Worth District will notify the Division Engineer, Southwestern Division, Corps of Engineers of any deviations or modifications of the water control plan and request his approval. The Division Engineer has been designated as the authorized representative of the Chief of Engineers in matters relating to projects within the Southwestern Division which are subject to provisions of Section 7 of the 1944 Flood Control Act.

(b) Reports to the Corps of Engineers. (1) The Authority shall furnish the District Engineer, Fort Worth District, U.S. Army Corps of Engineers, by 0900 hours daily, with the following:

(i) Project information.

(A) Lake elevations at midnight and 0800 hours.

(B) Uncontrolled spillway, flood-control conduits, and turbine releases: Cubic feet per second at 0800 hours, and day-second-feet average for the previous 24 hours, ending at midnight.

(C) Computed average inflow, in day-second-feet for the previous 24 hours, ending at midnight.

(D) Total precipitation in inches for the previous 24 hours at the dam, ending at 0800 hours.

(E) Summary of streamflow and channel conditions at gages named in paragraphs (a)(2) and (a)(4)(i) of this section.



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(ii) Lake Buchanan Pool elevation at 0800 hours.

(2) Whenever flood conditions are imminent, or stages of 16 feet (20,000 c.f.s.) or more at the Austin gage have been reached, the Authority shall report at once to the District Engineer by the fastest means of communications available. Data listed in paragraph (b)(1) of this section shall be reported to, and at intervals prescribed by the District Engineer for the duration of flood surveillance and control operations.

(Sec. 7, Pub. L. 78-534, 58 Stat. 890 (33 U.S.C. 709))

44 FR 24552, Apr. 26, 1979; 44 FR 29050, May 18, 1979]

## **Excerpt and Tables from the USACE Marshall Ford Reservoir Water Control Manual**

### Flood Operating Criteria

Regulation of flood control storage space in Marshall Ford Dam has as its major objective, the control of floods along the Colorado River below the dam. In order to achieve this objective, regulation of the reservoir between elevations 681.0 feet msl and 691.0 feet msl is primarily for flood control and secondarily, for power production. Reservoir storage from elevations 691.0 feet msl and 714.0 feet msl shall be considered exclusive flood control and releases will be determined by the Corps of Engineer's District Engineer except for releases required to meet irrigation, other downstream conservation requirements, or as may be required to protect the dam and reservoir from major damage.

Instructions for flood control will be made by the Corps District Engineer and provided to LCRA. When the reservoir is in the surcharge or general conservation storage pools, the District Engineer may make recommendations to the Regional Director for regulation in the interest of flood control, but such recommendations shall not be considered mandatory, as regulation of surcharge storage is the responsibility of the U.S. Bureau of Reclamation.

(as of March 2002)

**River Stage Levels<sup>1</sup> and  
Lake Operating Elevations<sup>2</sup>**

**Upstream from the Highland Lakes:**

Location	Bankfull Stage	Flood Stage
Colorado River at Winchell	24 ft	26 ft
Pecan Bayou near Mullin	20 ft	40 ft
San Saba River at Menard	12 ft	18 ft
San Saba River near Brady	16 ft	30 ft
San Saba River at San Saba	20 ft	24 ft
Colorado River near San Saba	25 ft	30 ft
Llano River near Junction	12 ft	16 ft
Llano River near Mason	6 ft	13 ft
Beaver Creek near Mason	9 ft	12 ft
Llano River at Llano	10 ft	10 ft
Sandy Creek near Kingsland	8 ft	12 ft
Pedernales River near Fredericksburg	12 ft	22 ft
Pedernales River near Johnson City	13 ft	14 ft
Barton Creek at Loop 360	8 ft	11 ft

**Highland Lakes and other Reservoirs:**

Lake	Dam	Operating Range	Spillway Crest	Dam Crest	Turbines	Floodgates
Brownwood	Brownwood	1405.5 – 1424.6' MSL	1424.6' MSL	1449.5' MSL	N/A	N/A
Brady Creek	Brady Creek	1712 – 1743' MSL	1762.4' MSL	1783' MSL	N/A	N/A
Buchanan	Buchanan	<1018' MSL (May-Oct) <1020.35' (Nov-Apr)	1020.35' MSL	1025' MSL	3 @ 1900 cfs	30 @ 7250 cfs, 7 @ 19000 cfs
Inks	Inks	886.9 – 887.7' MSL	888.2' MSL	922' MSL	1 @ 3400 cfs	N/A
LBJ	Wirtz	824.4 – 825.0' MSL	835.25' MSL	838' MSL	2 @ 4700 cfs	10 @ 30000 cfs
Marble Falls	Starcke	736.2 – 737.0' MSL	738.0' MSL	738' MSL	2 @ 4100 cfs	10 @ 9500 cfs
Travis	Mansfield	< 681' MSL cons. pool 681 – 750' MSL flood pool	714.1' MSL	750' MSL	3 @ 2400 cfs	24 @ 5700 cfs
Austin	Miller	491.8 – 492.8' MSL	492.8' MSL	519' MSL	2 @ 1750 cfs	5 @ 8600 cfs, 4 @ 14000 cfs
Town Lake	Longhorn				N/A	
Decker	Decker		530' MSL	563' MSL	N/A	2 (45x25')
Bastrop	Bastrop		425' MSL	458' MSL	N/A	2 (45x25')
Cedar Creek	Fayette				N/A	

**Downstream from the Highland Lakes:**

Location	COE Control Stage (<710')	COE Control Stage (>710')	Bankfull Stage	Minor Flood Stage	Moderate Flood Stage	Major Flood Stage
Colorado River at Austin	20.5 ft	24.8 ft	16 ft	24 ft		
Onion Creek at Hwy 183			15 ft	17 ft		
Colorado River at Bastrop	25.1 ft	26.7 ft	14 ft	23 ft		
Colorado River at Smithville			10 ft	20 ft		
Colorado River at LaGrange			19 ft	26 ft		
Colorado River at Columbus	35.5 ft	35.5 ft	30 ft	34 ft	39 ft	43 ft
Colorado River at Wharton			20 ft	39 ft	41 ft	43 ft
Colorado River at Bay City			23 ft	44 ft	45 ft	46 ft
San Bernard R. at E. Bernard			13 ft	17 ft	23 ft	28 ft

<sup>1</sup> River stage levels set by National Weather Service or by U.S. Army Corps of Engineers (COE).

<sup>2</sup> Lake operating elevations set by operating entity, COE or by Texas Water Development Board.

END



## **B-2 Agreement between LCRA and the Federal Emergency Management Agency**



## Lower Colorado River Authority

Post Office Box 220 Austin, Texas 78767 • (512) 473-3200

2/9/90 for  
signature - cr

March 26, 1990

John Matticks  
Federal Emergency Management Agency (FEMA)  
500 C Southwest, Room 423  
Washington, DC 20472

Re: Operating Agreement

Dear Mr. Matticks:

By letter of March 2, 1990, two signed copies of the agreement by and between the Federal Emergency Management Agency and the Lower Colorado River Authority regarding revised operating procedures for Buchanan, Roy Inks, Alvin Wirtz, and Max Starcke Dams were forwarded to this office. Enclosed is one fully executed copy of the agreement, as you requested. The other copy has been retained for our files.

It is hoped that this will serve to facilitate the processing of FIS's for Burnet and Llano Counties. If you have any questions, please do not hesitate to contact Wes Birdwell of my staff at (512) 473-4060.

Sincerely,

Gene Richardson, P.E., Director  
Water Resources Division

GR:WB:cr:021  
Enclosures

AGREEMENT BY AND BETWEEN  
LOWER COLORADO RIVER AUTHORITY  
AND  
FEDERAL EMERGENCY MANAGEMENT AGENCY

This Agreement made by and between the Lower Colorado River Authority, an agency of the State of Texas, hereinafter called LCRA, and the Federal Emergency Management Agency, an agency of the Federal Government, hereinafter called FEMA.

WHEREAS, FEMA is statutorily charged with and has a direct interest in reducing flood losses in the United States;

WHEREAS, FEMA is statutorily charged with delineating the areas of the United States containing special flood hazards;

WHEREAS, FEMA has, pursuant to its statutory mandate, defined areas of special flood hazards as those areas subject to a one-percent chance of inundation in any given year (100-year frequency flood);

WHEREAS, significant areas of Burnet and Llano Counties, Texas, have been delineated by FEMA as containing special flood hazards;

WHEREAS, operation by LCRA of Buchanan, Roy Inks, Alvin Wirtz, and Max Starcke Dams on the Colorado River, Texas, licensed to LCRA under Certificates of Adjudication issued by the Texas Water Commission, in a manner consistent with the terms contained herein will render many of the areas presently designated as special flood hazard areas as no longer subject to a one-percent chance of flooding in any given year;

WHEREAS, in those areas removed by FEMA from the special flood hazard area designation, the federal requirements to purchase flood insurance and to develop so as to protect against the 100-year frequency flood will no longer apply thus leaving property owners in those areas vulnerable to the 100-year flood unless LCRA performs in a manner consistent with the terms contained herein;

Now, therefore, the parties agree as follows:

1. To induce FEMA to enter into this agreement, LCRA has represented to FEMA that it will provide for the regulation of the flow of flood waters past Buchanan, Roy Inks, Alvin Wirtz, and Max Starcke Dams, on the Colorado River in Burnet and Llano Counties, Texas, by operating as follows:

- a. Lake Buchanan Operations Procedure

- i) Flood flows into Lake Buchanan will be estimated utilizing the USGS gage station Colorado River near San Saba (USGS Gage Number 08147000). These will be continuously monitored by LCRA's Hydrometeorological Data Acquisition System and verified by LCRA personnel observation.
- ii) Lake Buchanan will be maintained at or below elevation 1018.00 feet ngvd during the flood season (May through October). During all other months, the water surface elevation will be maintained at or below the top of the defined conservation pool (1020.35 feet ngvd).
- iii) During flood season, releases will be made under the following guidelines:

RISING LIMB OF HYDROGRAPH

Gaged Inflow < 22,000 cfs    Outflow < 22,000 cfs  
Gaged Inflow > 22,000 cfs    Outflow = .85 x (Gaged Inflow)

FALLING LIMB OF HYDROGRAPH

Outflow ≤ Maximum Outflow (until lake returns to the conservation pool)

After gage inflows exceed 22,000 cfs, at no time later shall the peak release during the event exceed the instantaneous peak discharge of the inflow hydrograph.

- iv) The total number of 33'x15.5' gates open shall be limited to 20 unless the forecast elevation for the lake exceeds 1021.3 feet ngvd. Should higher elevation be forecast, additional gates will then be opened as necessary.

b. Lake Inks Operations Procedure

- i) As Inks Dam's primary discharge structure for a flood event is an uncontrolled spillway, no special operations apply.

c. Lake LBJ Operations Procedure

- i) Flood flows into Lake LBJ will be estimated utilizing the USGS gage station Llano River at Llano (USGS Gage Number 08151500). These will be continuously monitored by LCRA's Hydrometeorological Data Acquisition System and verified by LCRA personnel observation.
- ii) Lake LBJ will be maintained between 824.40 and 825.00 feet ngvd under normal operating conditions. When a potential exists for flood inflow, the lake will be maintained at elevation 824.70 feet ngvd. Thereafter, the lake will be maintained, as possible, between the elevations 822.00 and 825.00 feet ngvd.
- iii) During passage of flood peaks equal to or smaller than the 100-year flood, the lake will not exceed elevation 828.00 feet ngvd.

d. Lake Marble Falls Operations Procedure

- i) Lake Marble Falls will be maintained between 736.20 and 737.00 feet ngvd under normal operating conditions. When a potential exists for flood inflow, the lake will be maintained at elevation 736.20 feet ngvd. Thereafter, elevations will be maintained, as possible, below 737.00 feet ngvd.

- 2. LCRA shall continue to use this operating plan until modified by order of an appropriate regulatory agency. If a regulatory agency issues an order modifying this operating plan, FEMA will be notified and may, at the discretion of the Federal Insurance Administrator, modify the Flood Insurance Rate Maps for Burnet and Llano Counties, Texas, accordingly.




3. In consideration of the obligations and duties undertaken by LCRA pursuant to the terms of Section 1 of this agreement and in exchange therefor, FEMA shall modify its Flood Insurance Rate Maps for Burnet and Llano Counties, Texas, and any successor maps to reflect the flood protection afforded by LCRA's regulation of Buchanan, Roy Inks, Alvin Wirtz, and Max Starcke Dams on the Colorado River Reservoir system set out in Section 1 of this agreement.
4. It is recognized by and between the parties hereto that the terms of the agreement have been bargained for and given in exchange and as inducement for each other.

In Witness Whereof, the parties have executed this instrument on the dates noted below.

Lower Colorado River Authority


By: \_\_\_\_\_

  
Mark Rose DEW  
Deputy General Manager

3-8-90  
Date

Federal Emergency Management Agency

By: \_\_\_\_\_

  
Harold T. Duryee  
Federal Insurance Administrator

2-28-90  
Date

END

## Prior Orders regarding LCRA's Water Management Plan and Firm Water Curtailment Plan

Appendix C-1: Order Approving LCRA's Water Management Plan and Amending Certificate of Adjudication - September 20, 1989

Appendix C-2: Order Approving LCRA's Drought Management Plan - December 23, 1991

Appendix C-3: Agreed Order Approving Amendments to LCRA's Water Management and Drought Management Plan – December 18, 1982

Appendix C-4: Agreed Order Approving Amendments to LCRA's Water Management and Drought Management Plan – March 1, 1999

Appendix C-5: Order overruling objections to LCRA's system of priorities set forth in its Water Management Plan - June 3, 2003.

Appendix C-6: Agreed Order Approving Amendments to LCRA's Water Management Plan – January 27, 2010

Appendix C-7: Order Approving LCRA's Firm Water Curtailment Plan – December 12, 2011

Appendix C-1  
Order Approving LCRA's Water Management Plan and  
Amending Certificate of Adjudication  
Nos. 14-5478 and 14-5482,  
Dated September 20, 1989

# TEXAS WATER COMMISSION



IN RE: CONSIDERATION OF §  
THE LOWER COLORADO RIVER § BEFORE THE  
AUTHORITY'S WATER MANAGEMENT §  
PLAN AND AMENDMENTS TO § TEXAS WATER COMMISSION  
CERTIFICATES OF ADJUDICATION §  
NOS. 14-5478 AND 14-5482 §

## ORDER APPROVING LOWER COLORADO RIVER AUTHORITY'S WATER MANAGEMENT PLAN AND AMENDING CERTIFICATES OF ADJUDICATION NOS. 14-5478 AND 14-5482

On the 7th day of September, 1989, the Texas Water Commission ("Commission") held a public hearing to consider the Lower Colorado River Authority's Water Management Plan and applications to amend Certificates of Adjudication Nos. 14-5478 and 14-5482. At the hearing, the following were named as parties: the Lower Colorado River Authority; the Texas Parks and Wildlife Department; the City of Austin; the Garwood Irrigation Company; the Sierra Club, Lone Star Chapter; the Texas Farm Bureau; the Matagorda County Water Council; Houston Lighting and Power Company as Project Manager for the South Texas Project; Clear, Clean Colorado River Association; Pierce Ranch; the Village of Lakeway; the Executive Director of the Texas Water Commission; and the Public Interest Counsel of the Texas Water Commission. Having considered the evidence and arguments presented, the Commission makes the following Findings of Fact and Conclusions of Law:

### FINDINGS OF FACT

1. Notice of the adjudicative public hearing was published on July 26, 1989, in the Blanco County News, Austin American-Statesman and the Colorado County Citizen, newspapers regularly published and generally circulated in Blanco, Travis and Colorado Counties, Texas, respectively; on July 27, 1989, in the San Saba News and Star, Llano News, Highlander and the Bay City Daily, newspapers regularly published and generally circulated in San Saba, Llano, Burnet, and Matagorda Counties, Texas, respectively; on July 28, 1989, in the Fayette County Record, a newspaper regularly published and generally circulated in Fayette County, Texas; on July 29, 1989, in the Wharton Journal-Spectator, a newspaper regularly published and generally circulated in Wharton County, Texas, and on July 31, 1989 in the Bastrop Advisor, a newspaper regularly published and generally circulated in Bastrop County, Texas, the only counties in which persons reside who may be affected by action taken as a result of the hearing. Said notice was published not less than thirty days before the date of the hearing.

2. On July 26, 1989, notice of the public hearing was sent by first-class mail to persons who may be affected by action taken as a result of the hearing and to each person as required by law.
3. The Lower Colorado River Authority (LCRA) is requesting approval of its Water Management Plan for the Lower Colorado River, Colorado River Basin in accordance with the Court's Final Judgment and Decree entered in Cause No. 115,414 A-1, 264th Judicial District, In Re: The Exceptions of the Lower Colorado River Authority and the City of Austin to the Adjudication of Water Rights in the Lower Colorado River Segment of the Colorado River Basin, and is further requesting approval of amendments to Certificates of Adjudication Nos. 14-5478 and 14-5482 to authorize LCRA to divert, release and use the water in Lakes Buchanan and Travis for additional beneficial uses including domestic, recreation, instream flow and bays/estuary purposes.
4. LCRA's Water Management Plan consists of two volumes. Volume I, Policies and Operations, describes the issues and conflicts in the demands on the Colorado River system and lays out the policies and management actions LCRA will use to accommodate the variety of demands on the system. Volume II, Technical Report, describes the models and data sources and the process used for the determination of the Combined Firm Yield and the Annual Rule Curve methodology. Volume II includes a set of Appendices consisting of the Court's Final Judgment and Decree, and the detailed data used to support the recommendations and conclusions discussed in Volumes I and II.
5. The Highland Lakes Reservoirs are operated by LCRA as a system for flood control and water supply. Mansfield Dam is the only structure with a dedicated flood pool and is operated during flooding according to flood-control regulations as published in the Code of Federal Regulations and under the supervision of the U.S. Corps of Engineers.
6. LCRA has a remote data acquisition system referred to as "Hydromet." The Hydromet allows for remote interrogation of a networked system of twenty-one self-reporting rainfall gages, twenty-two remotely monitored streamflow gages and six reservoir elevation gages. Twenty of the streamflow gages also gather rainfall information, giving a total of forty-one rainfall sites. The network is polled each hour, and all data is verified and stored in a real-time data base on a central computer system. Communications are a combination of microwave and UHF radio. The relational data provided by the Hydromet monitors flows above and below the lakes.
7. LCRA has a central computer system that is composed of two Digital Equipment Corporation MicroVAX II mini computers, one

of which is designated as an operations system located at the LCRA System Operations Control Center, and the other designated as a development system located at the Water Resources office. Real time data is logged and maintained on an on-line historical data base for one year. This is available for access by operations models, historical analyses, or other needs.

8. LCRA has developed several hydrologic models that are models used for routine operations of the system. Each model was developed to meet specific operational needs. The Daily Operations Model, analyzes the downstream inflow and demands by accessing streamflow data, totalling demands, and making multiple computer runs of the Model. The Flood Management Model is a user oriented operation tool which accesses real-time data and routes flood flows through the Highland Lakes. The Storage Projection Model uses historical inflow data to estimate the reliability of reservoir system storage subject to storage conditions and water demands.
9. The Daily Allocation Model will determine the extent to which releases from storage are diverted. It will perform a water balance every twenty-four hours at each river gage below Tom Miller Dam, and will allocate the natural flow of the river (whether or not it originated upstream or downstream of the lakes) to major water rights holders to the extent it is available. The remaining portion, if any, of each diversion is assumed to have been from water released from storage. Each amount is then totaled for the week, month and year to determine the total demand on storage.
10. Daily Operations are a joint effort between the System Operations Control Center (SOCC), Hydro Operations personnel located at the dams, and Water Operations personnel located at the Central Office complex. Water Operations personnel determine the required release by contacting downstream customers, operating the Daily Operations Model, and posting the daily release schedule. The SOCC then determines the optimum time and during the day to release the water based on the daily power peak demand, and orders the hydro generation units to begin and end at the necessary times. Hydro Operations personnel at each dam determine which unit to run at each dam.
11. The standard operating levels for the Highland Lakes are: Lake Buchanan, 1020.35 feet; Inks Lake, 887.30 +/- 0.4; Lake LBJ, 824.70 +/- 0.3; Lake Marble Falls, 736.60 +/- 0.4; Lake Travis, 681.00; and Lake Austin, 492.30 +/- 0.5. All levels are referenced to mean sea level.
12. The U. S. Corps of Engineers is evaluating potential flood damages to areas both upstream and downstream of Mansfield

Dam. LCRA is cooperating in this study. The Corps is also performing a reconnaissance study of possible additional flood control and water supply reservoirs. LCRA is cooperating in this study as well.

13. The Highland Lakes System consists of Lakes Buchanan, Inks, LBJ, Marble Falls, Travis and Austin.
14. LCRA's water rights for Lakes Buchanan, Inks, LBJ, Marble Falls and Travis are set forth in Certificates of Adjudication Nos. 14-5478, 14-5479, 14-5480, 14-5481 and 14-5482. LCRA operates Tom Miller Dam (the dam creating Lake Austin) pursuant to agreement with the City of Austin. Austin's water rights for Lake Austin are set forth in Certificate No. 14-5471.
15. LCRA's water rights on the Colorado River below the City of Austin are set forth in Certificates of Adjudication Nos. 14-5437, 14-5473, 14-5474, 14-5475, and 14-5476.
16. LCRA's right to use the waters of the Highland Lakes is subject to the terms and conditions as set out in the final judgment and decree dated April 20, 1988, in Cause No. 115, 414-A-1.
17. LCRA is committed to following the terms and conditions of the final judgment and decree dated April 20, 1988 in Cause No. 115, 414-A-1.
18. LCRA's first step in development of its Water Management Plan was a comprehensive review of LCRA's Board policies and existing programs that guide and shape the way LCRA manages the river system. The LCRA Board of Directors held a series of monthly public meetings and received testimony from LCRA staff, outside experts, and numerous representatives of diversified constituencies including state agencies, environmental groups, business, industry, agricultural interests, and wholesale electric customers. Based upon the evidence the Board received new comprehensive water policies were adopted by the LCRA Board. These policies form the foundation of the Plan.
19. LCRA's next step was the formulation of a Public Task Force. The LCRA staff and public task force met and worked together over a 6 month period.
20. A draft of the Technical Report (Volume II) of the Water Management Plan was transmitted to the Commission on December 30, 1988. A draft of both Volumes I and II of the Plan was submitted to the Commission's staff and distributed to the public in February 1989 for public comment, LCRA held public workshops followed by local meetings in Bay City, Eagle Lake

and at Buchanan Dam. Additionally, public discussions during LCRA Board meetings were held in March, April and May 1989. LCRA formally adopted the Plan in May 1989.

21. LCRA's proposed Water Management Plan was filed with the Commission on July 7, 1989. The Commission acknowledged receipt of LCRA's proposed Plan on July 18, 1989.
22. LCRA's Water Management Plan has essentially four criteria. One is that the Highland Lakes and the Colorado River downstream will be managed together as a single system for downstream water supply purposes. The second is that the beneficial use of the water derived from inflows below the Highland Lakes will be maximized. The third is that LCRA will stretch and conserve the waters stored in the Highland Lakes and advance water quality. The fourth is that adequate flows will be provided to maintain, and where reasonably possible, improve, fish, wildlife, and recreation resources in the Lower Colorado River and to maintain a proper ecological environment and health of related living marine resources in the Lavaca-Tres Palacios Estuary, to the extent it is affected by the lower Colorado River watershed.
23. LCRA will follow five guidelines in implementing its Water Management Plan including:
  - a. All demands for water from the Colorado River downstream of the Highland Lakes will be satisfied to the extent possible by run-of-river flows of the Colorado River;
  - b. Inflows will be passed through the Highland Lakes to honor downstream senior water rights only when those rights cannot be satisfied by the flow in the river below the Highland Lakes;
  - c. The firm, uninterruptible commitments of water from Lakes Travis and Buchanan will not exceed the Combined Firm Yield;
  - d. Water from Lakes Travis and Buchanan will be available on an interruptible basis only as long as LCRA's ability to meet the demand for uninterruptible water is not impaired;
  - e. Water shall not be released through any dam solely for hydroelectric generation, except during emergency shortages of electricity, and during other times that such releases will be needed for another beneficial purpose.
24. LCRA has the ability to constantly monitor the amount of water in the river available to meet demands through the Hydromet



System which should allow full utilization of the flows originating below Lake Travis prior to making any releases from storage or passing inflows through the reservoirs.

25. Under the Water Management Plan the four downstream irrigation operations (Gulf Coast, Lakeside, Garwood, and Pierce Ranch) will have first priority for the interruptible water in the annual allocation process. This priority will be set by establishing a Conservation Base for LCRA's two irrigation districts. LCRA intends to negotiate a contract which will include a Conservation Base acreage with Pierce Ranch. The Conservation Base acreage for Gulf Coast, Lakeside and Pierce Ranch was determined on the basis of a ten-year (1976-1985) historical average of actual production acreage. The allocation of water for these three users is based on a duty of 5.25 acre-feet of water per acre irrigated. The priority allocation and terms governing the interruption of supply of stored water for Garwood are based upon a contract between Garwood and LCRA. The 5.25 acre-foot-per-acre duty also applies to Garwood irrigated acreage. In the annual allocation process Lakeside has a priority to interruptible stored water in an amount necessary to firm up run-of-river rights to 136,500 acre-feet per year; Gulf Coast an amount necessary to firm up run-of-river rights to 194,250 acre-feet per year and Garwood an amount necessary to firm up run-of-river rights to 168,000 acre-feet per year.
26. When the federal allocation for the number of acres of rice that can be grown exceeds the Conservation Base acreage of Lakeside and Gulf Coast, then in that year LCRA will provide back up stored water for up to 28,300 acres at Lakeside and 42,800 acres at Gulf Coast. These limits represent the maximum number of acres served by each of the two divisions during the 10 year historic period that was used to establish the Conservation Base. For the Lakeside Division, any acreage over 25,000 and up to 28,300 can be served from an alternate source.
27. Lake levels follow an annual cycle--that of filling the conservation storage space in the winter and spring months of the year to be drawn down by larger water uses during the summer months.
28. Because these multiple purpose reservoirs were not constructed for recreational use, the demands for stability in the reservoir levels by recreation interests present conflicts which are extremely difficult to accommodate. If limits are to be placed on how far down the reservoirs' water levels are allowed to decline, a corresponding limitation on the amount of water that is available to supply the other demands on the reservoir system must also be agreed to.

29. To the extent that the annual analysis of the amount of water in storage reveals that there are interruptible water supplies available after meeting the demands of the irrigation operations, interruptible water may be held in the reservoirs to better ensure the security of supply or to maintain lake levels.
30. If additional sales of interruptible water exceed the Conservation Base amounts and the priority allocation for Garwood would draw the lakes below these minimum levels the LCRA Board will not declare any additional interruptible water available for sale in that year. Those levels are 660 feet msl for Lake Travis and 1012 feet msl for Lake Buchanan. LCRA is not guaranteeing minimum lake levels.
31. Another item to help keep the levels of Lakes Buchanan and Travis as high as possible is the agreement that no maintenance, except for emergencies, which would require the lowering of Lakes LBJ, Marble Falls, and Inks will be permitted if the refilling of those lakes would draw the levels of Lakes Travis and Buchanan below the minimum levels. Periodic lowering and refilling of Lake Austin will be done pursuant to the Settlement Agreement (December 10, 1988) between LCRA and the City of Austin.
32. Downstream recreation interests may be enhanced by LCRA's commitment to maintain minimum instream flows. LCRA will develop additional boat launches and recreation areas on the river through LCRA's 10-county district in order to give the public better access to the Colorado River.
33. Hydroelectric power plants located in each of the dams owned and operated by LCRA total 242 megawatts of capacity. Hydropower generally has been subordinated to be a by-product of the release of water for other purposes. LCRA retains the right to make releases solely for hydropower production in times of emergency as part of the Water Management Plan operating policies.
34. LCRA and Texas Parks and Wildlife Department (TPWD) have entered into a Memorandum of Understanding (MOU), wherein the LCRA and TPWD have agreed that LCRA's Water Management Plan would have a goal of maintaining, and where reasonably possible, improving fish, wildlife, and recreation resources in the Lower Colorado Watershed and of maintaining a proper ecological environment and health of related living marine resources in the Lavaca-Tres Palacios Estuary, to the extent that it is affected by that watershed. Some of the provisions addressed in the MOU have been included in LCRA's Water Management Plan.

35. LCRA and TPWD currently are studying the instream flow issue. These studies are scheduled for completion in March 1991.
36. Until the instream flow studies are complete, LCRA will commit to maintaining a minimum monthly mean flow of 200 cfs throughout the lower basin. This flow may, at times, be satisfied from inflows into the river channel and releases made by LCRA to satisfy the demands of downstream users. To assure that sufficient water will be available to satisfy this instream flow demand, LCRA has allocated 25,000 acre-feet of firm water supply to back up this demand on the system and the demand for inflows into the bays and estuaries.
37. Fresh water inflows are essential to maintenance of the productivity of the bays and estuaries. Preliminary data indicate that the amount of inflows needed for the Lavaca-Tres Palacios Estuary may represent the largest single demand on the system. TPWD and the Texas Water Development Board (TWDB) are currently studying the issue of how much fresh water is necessary to maintain the productivity of the bays and estuaries. The study is scheduled for completion by the end of 1989 with public review scheduled during 1990.
38. Until the bays and estuaries study is completed, LCRA has committed to a minimum monthly mean flow of 200 cfs, a minimum seasonal mean flow of 375 cfs, and a minimum annual flow of 272,121 acre-feet for the bays and estuaries. Measurements are to be made at the USGS gage at Bay City. This flow may at times be satisfied from inflows into the river channel, releases of stored water by LCRA for downstream uses and runoff or tailwaters from the rice irrigation operations. These flows will be backed up with 25,000 acre-feet of firm supply water which is also available for instream flow demands.
39. The Texas Water Development Board (TWDB) and the U.T. Bureau of Economic Geology are currently studying the Carrizo-Wilcox and Gulf Coast Aquifers. LCRA is studying the feasibility of the use of groundwater resources in conjunction with interruptible surface water supplies including the evaluation of artificial recharge of depleted aquifer storage space.
40. Under the existing LCRA Water Pricing Policy the rates for purchasing water must recover the costs associated with the Water Management Plan including necessary funds for water quality and conservation activities.
41. The water to be captured by the Stacy Reservoir are waters that otherwise would have flowed into Lake Buchanan. LCRA determined that the appropriate approach at this time was to calculate the firm yield of the Stacy reservoir separately

from the Highland Lakes, then add it back in, to give the total combined firm yield for Lakes Buchanan and Travis.

42. LCRA used a standard single reservoir operation model to determine the firm yield of the Stacy Reservoir. Inputs to the model included: inflow, net evaporation, monthly water demand distribution, and area/capacity curve for the reservoir.
43. LCRA used a multiple reservoir operations model to determine the combined firm yield of Lakes Buchanan and Travis. User defined local water demands were assumed at each of the reservoirs. Inputs to the model included: inflows, net evaporation, local water demands, monthly water demand distribution, minimum and maximum allowable contents, and area/capacity curves for each reservoir.
44. The period of 1941-1965 was used in the determination of the combined firm yield which includes the worst drought of record encountered.
45. Hydrologic data was related to reservoir inflow. The inflow that actually occurred in the record drought was adjusted to simulate a future time period. The monthly values of inflow to Lakes Buchanan and Travis for the period of January 1940 through December 31, 1972 provided to LCRA by TWC water availability model were adjusted. Under the approach used at this time by LCRA to determine the combined firm yield, the simulated operations of Stacy Reservoir did not pass flow to fulfill downstream senior run-of-the-river water rights.
46. LCRA determined how much water was necessary to satisfy daily water demands at a specific location to the extent that flow is available in the river at that point on that specific day. LCRA found that the average annual unsatisfied demand was 520,657 acre-feet; the maximum annual unsatisfied demand was 674,095 acre-feet; and minimum annual unsatisfied demand was 340,500 acre-feet.
47. LCRA determined that the firm yield of the Stacy Reservoir is 90,546 acre-feet. The combined firm yield of Lakes Buchanan and Travis without inflow from upstream of Stacy Reservoir is 445,266 acre-feet/year. Adding the firm yield of Stacy Reservoir results in the combined firm yield for Lakes Buchanan and Travis of 535,812 acre-feet/year which represents the maximum average annual demand that can be met by these two lakes during a repetition of the most critical drought of record on the lower Colorado River. The combined firm yield may also be expressed as a total of 2,679,060 acre-feet over any five consecutive calendar-year period.

48. LCRA developed a rule curve which defines the ability of Lakes Buchanan and Travis to meet annual demands in excess of the combined firm yield, while reserving an adequate supply to meet firm demands.
49. Starting with the reservoirs full, various demands ranging from .781 million acre-feet to 1.5 million acre-feet were placed on the system for the period. It was found that even at a demand of 1.5 million acre-feet per year 100% of the demand was met in 46% of the years; 75% of the demand was met in 63% of the years; and the amount of .781 million acre-feet was met in 80% of the years.
50. This annual rule curve is considered conservative to the degree that the effect of a critical short-term drought equal to or less severe than historical will be negligible only if total firm demands are less than the combined firm yield.
51. The annual operations rule curve will analyze projected annual demands and based on October 1 lake levels will guarantee the supply of water for firm demands and identify an annual amount of water which may be used for non-firm purposes. It will be modified as firm demands increase, and as hydrologic conditions change in the Colorado River Basin.
52. The operational rule curve will be applied to the system on a monthly basis to determine how the system is responding to current conditions as compared to historical operations. This will allow LCRA to optimize reservoir operations on a real time basis and to determine if adjustments to the amount of interruptible water are necessary. This monthly analysis will help LCRA detect early signs of drought and allow LCRA to timely develop and implement drought contingency measures.
53. The amount of water required to meet the firm demand within the system for the preceding year will be calculated in early October. This amount will be compared to the projections for that year, and any variations will be noted and documented. LCRA will solicit information and projections of use from all of its firm supply contract holders and other firm uses provided for by resolution of the LCRA Board. This information will be used to develop a projection of firm demands for the coming year.
54. LCRA will assess the contents of Lakes Travis and Buchanan as of October 1 to project the storage levels for January 1 of the next year. Inflows into Lakes Travis and Buchanan from the upstream tributaries will be added to this preliminary storage level based on the minimum annual inflow from the period of drought. This process will allow LCRA to reserve sufficient water in the system to meet all firm demands for one year beyond the year being considered for allocations.

Estimates for firm demand commitments for the next year will be subtracted from the total water supply available. The amount of water remaining will then be available for interruptible allocation for that year.

55. In October, LCRA will publish the results of the allocation process, notify the LCRA Board, firm contract holders, the Texas Parks & Wildlife Department and any existing or potential interruptible contract holders. During the October LCRA Board meeting information will be presented to the Board and discussed.
56. The recommended annual allocation plan will be published and LCRA will consider public comments and will take into account any significant water events that may have occurred up to the date of publication. The annual allocation plan will be submitted as a recommendation for LCRA Board approval in November of each year.
57. The portion of the combined firm yield that is not yet committed and the firm uninterruptible water that is committed but not yet being used increases the interruptible water that is available each year. The water that is captured and stored from flood flows also adds to the amount of interruptible water that is available. Over time, as the current contracts draw fully on their commitments and the remainder of the firm yield is contracted for, there will be less interruptible water available on an annual basis.
58. LCRA has committed the following amounts out of the combined firm yield amount:
  - a. Stacy Reservoir - the maximum impact of Stacy Reservoir on the firm yield of Lakes Travis and Buchanan is an average of 90,546 acre-feet per year.
  - b. City of Austin - LCRA has agreed to firm up or supplement Austin's independent water rights to the extent of 290,156 acre-feet per year. A commitment of an average of 148,300 acre-feet per year of stored water is necessary to meet this demand.
  - c. Highland Lakes Water Sale Contracts - municipal and industrial contracts total 104,754 acre-feet per year.
  - d. Cooling Water for LCRA Power Plants - LCRA Board Resolution of January 22, 1987 committed 15,000 acre-feet for Ferguson; 10,750 acre-feet for Sim Gideon and 38,101 acre-feet for Fayette Power Project for a total of 63,851 acre-feet per year.

- e. South Texas Project (STP) - LCRA has a contract to supply industrial water to STP in an amount up to 102,000 acre-feet per year. The commitment is met first by run-of-river water, firmed-up by stored water from Lakes Buchanan and Travis. Simulated operations through the drought of record showed a demand for stored water in one year of 51,700 acre-feet. A commitment of an average of 5,680 acre-feet per year of stored water is necessary to meet this demand.
- f. Instream Flows and Bay/Estuary Needs - LCRA is also committing (reserving) 25,000 acre-feet out of the combined firm yield to meet instream flows and bay and estuaries' needs.
59. LCRA is reserving 50,000 acre-feet of the remaining combined firm yield for future uses under LCRA's certificates of adjudication. This reservation will be until water supply and demand assessments for LCRA's 10-county district are completed or within three years whichever is sooner.
60. The uncommitted balance of the combined firm yield of Lakes Buchanan and Travis is 47,681 acre-feet per year.
61. LCRA is in the process of developing a drought management plan and will be submitting the plan to the Commission in 1990.
62. LCRA is conducting county-by-county assessments of alternative water supply sources. This data will be useful in the development of local drought management plans.
63. The goal of LCRA's conservation programs is to promote the development and application of practices and technologies that will improve water use efficiency, increase the beneficial re-use of water, and minimize the waste of water.
64. LCRA's water conservation programs are directed at the two largest users of water, irrigated agriculture and municipal.
65. LCRA's goal for conservation of water used by irrigated agriculture is to reduce agricultural demands for stored water from the Highland Lakes and reduce costs associated with the operation of LCRA-owned irrigation water delivery systems in Colorado, Wharton and Matagorda Counties.
66. LCRA's current irrigated agriculture conservation programs consist of activities aimed at improving the operating efficiency of irrigation water delivery systems and improving on-farm water use efficiency.
67. The major elements of the irrigation canal rehabilitation program include: improved operational control and management

of the system; vegetation removal and control; improved hydraulics characteristics of canals; installation of water control and measurement structures; and automation of water diversion facilities.

68. The irrigated canal rehabilitation program is expected to reduce water use by 30 percent within the Gulf Coast canal system. Preventive maintenance at Lakeside is expected to maintain canal efficiency.
69. The major elements of the on-farm water conservation program include: Direct support through funding and staff for the Cooperative Rice Water Management Research Program; assistance with the transfer of information from the research arena to the rice producer; conservation demonstrations such as the development and testing of an automated levee gate; and the inclusion of water conservation stipulations in LCRA's standard irrigation water sale contract.
70. Preliminary results indicate that on-farm water use can be reduced by 25 to 30 percent.
71. LCRA's municipal water conservation programs are directed towards implementation of urban water conservation and water re-use. Focus is towards encouraging and supporting local level initiatives by more than 300 public water utility systems within LCRA's statutory district.
72. The five major elements of LCRA's municipal water conservation programs are:
  - a. Direct technical assistance with the development and implementation of local water conservation programs including public awareness and education; water efficiency standards and guidelines for new construction (e.g., plumbing fixture efficiency standards); retrofit programs to improve water efficiency in existing developments; conservation-oriented water rates and other economic incentives; low-water-use landscaping (i.e., Xeriscape); and water re-use and recycling.
  - b. Distribution system audit and leak detection services for local water utilities serving fewer than 10,000 connections.
  - c. Integration of water conservation and re-use measures, as appropriate, with other LCRA programs and projects including LCRA water sale contracts; water resource planning and demand forecasting; water and wastewater utility service studies, projects, and service agreements; water rate design; environmental programs; and energy conservation programs.



- d. Public awareness and education on the water conservation opportunities, benefits, and measures. On-going activities include distribution of brochures, fact sheets, and videos on water conservation; media promotion (e.g., news articles, public service announcements, talk shows, etc.); presentations to civic and service organizations; and workshops, seminars, and special events.
  - e. Demonstrations of advanced water conservation and re-use technologies and low-water-use landscaping techniques.
- 73. LCRA will no later than December 31, 1991 reference and summarize existing information on point and nonpoint pollution sources and loading on the Colorado River including inputs of nutrients, metals, pesticides, oxygen demanding substances and other contaminants that may affect water quality, fish wildlife and recreation resources in accordance with the MOU with TPWD.
  - 74. LCRA will no later than December 31, 1991 identify new data needed to determine the effect of water quality on revision of minimum flow schedule and as soon as reasonably possible will modify its existing monitoring programs or new programs to collect such new data.
  - 75. LCRA is evaluating the potential problems associated with anoxic hypolimnetic releases from reservoirs and the potential for related fish kills due to resulting low dissolved oxygen levels downstream. LCRA will no later than December 31, 1991 reference and summarize this evaluation.
  - 76. LCRA has also applied to the Commission for an amendment to the Certificates of Adjudication Nos. 14-5478 and 14-5482 relating to Lakes Buchanan and Travis.
  - 77. Certificates of Adjudication Nos. 14-5478 (Lake Buchanan) and 14-5482 (Lake Travis) authorize LCRA to divert and use water from Lakes Buchanan and Travis for municipal, industrial, irrigation and mining purposes. LCRA is authorized to use the water impounded in Lakes Buchanan and Travis for recreation purposes with no right of diversion or release. LCRA is authorized to use the bed and banks of the Colorado River, below Lakes Buchanan and Travis to convey water released from Lakes Buchanan and Travis for use by LCRA or others entitled to use such water in the amounts and for the purposes authorized in the Certificates. LCRA is also authorized to divert and use water through Buchanan Dam and Mansfield Dam for the purpose of hydroelectric power generation.
  - 78. The Water Management Plan submitted by LCRA to the Commission for its consideration includes proposed reservoir operating

procedures whereby LCRA will divert or release waters stored in Lakes Buchanan and Travis for several additional purposes of use including domestic, recreation, instream flow and bays/estuary purposes.

79. In order to manage Lakes Buchanan and Travis as proposed in the Water Management Plan, LCRA's Certificates of Adjudication Nos. 14-5478 and 14-5482 need to be amended to authorize LCRA to divert, release and use the water in Lakes Buchanan and Travis for additional beneficial uses including domestic, recreation, instream flow and bay/estuary purposes.
80. As part of these amendments, LCRA is not requesting an additional amount of water. The proposed amendments will not result in an additional consumptive use of state water.
81. A "firm" demand is a contractual obligation or other commitment of LCRA's which must be met 100% of the time through the drought of record. Total firm demands will need to be less than or equal to the combined firm yield to be protected throughout recurrence of the drought of record.
82. Interruptible or "nonfirm" demands are LCRA's contractual obligations or other commitments for stored water which contractually do not have to be met 100% of the time. They will be met to the extent additional water is available each year after firm demands are satisfied.
83. LCRA has formally adopted standard water sale contract forms, and procedures and rules for administering water sale contracts. Existing contracts are written for firm supply of water, subject only to the general laws of availability. A second standard form contract for interruptible supply is presently being developed.
84. LCRA currently has no contracts upstream from the Highland Lakes, except those with upstream reservoirs with junior rights to the Highland Lakes which are more or less operation agreements.
85. Existing upstream operating agreements should be considered firm contracts, and their effect on the combined firm yield should be quantified as was Stacy Reservoir's effect.
86. Junior rights senior to November 1, 1987, will be honored as required by the Court's Judgment and Decree with interruptible supplies. Their diversions will be allocated similar to downstream senior rights.
87. A report which documents LCRA's compliance with the Water Management Plan during the previous year will contain information regarding the adequacy of the hydrologic and

hydraulic data monitoring system as to intensity and accuracy; accuracy of reported or monitored activities; adequacy of the operating rule curve and the adequacy of the daily allocation model and any additional information the Executive Director may request.

88. Under the approach used by LCRA at this time, the combined firm yield of Lakes Buchanan & Travis is 535,812 acre-feet/year. This amount may also be expressed as an average of a total of 2,679,060 acre-feet per year over any five consecutive calendar-year period.
89. LCRA's proposed Water Management Plan does not presently propose any new projects taking, storing or diverting water in excess of 5,000 acre-feet per year.
90. The use of an operational rule curve, as developed by LCRA, is an acceptable approach to insure utilization of the lakes' storage while at the same time guaranteeing that firm demands will be met dependably year after year.
91. LCRA's procedures and guidelines for the allocation of firm water and interruptible water supplies are acceptable, with the understanding that the allocation procedures may be amended at a later time to reflect the results of the instream flow and bay/estuary studies; provided, however, that the Commission shall retain jurisdiction to resolve all disputes regarding allocation of stored water that may arise in the future.
92. LCRA's initiatives regarding point and non-point sources of pollution are commendable.
93. The priorities in LCRA's Water Management Plan for interruptible water are subject to changes after the completion of the studies on the instream flows and bays/estuaries.
94. LCRA's proposed system operations under LCRA's Water Management Plan are consistent with the special conditions set forth in the Court's Final Judgment and Decree regarding LCRA's rights to use the waters of Lakes Buchanan and Travis.

#### CONCLUSIONS OF LAW

1. The public hearing was held under the authority and in accordance with Chapter 11 of the Texas Water Code, as amended and the Texas Water Commission Permanent Rules.
2. The Texas Water Commission has jurisdiction to consider LCRA's proposed Water Management Plan and applications to amend its Certificates of Adjudication.

3. LCRA's proposed Water Management Plan recognizes the necessity of beneficial inflows from the Colorado River into the Lavaca-Tres Palacios Estuary consistent with Section 11.147 of the Texas Water Code.
4. LCRA's proposed Water Management Plan recognizes the necessity of providing for the protection of fish and wildlife habitats and the water quality of the river as required by Section 11.147 of the Texas Water Code.
5. LCRA's proposed Water Management Plan recognizes the Commission's statutory authority to require water conservation and provides for water conservation consistent with Section 11.134(b)(4) of the Texas Water Code.
6. LCRA's applications to amend its Certificates of Adjudication Nos. 14-5478 and 14-5482 authorizing LCRA to use the waters of Lakes Buchanan and Travis for additional beneficial purposes do not contemplate an additional consumptive use of state water or an increased rate or period of diversion.
7. In order to effectuate the policies of this State relating to the conservation and best utilization of the water resources of this State as set forth in Chapter 11 of the Texas Water Code, LCRA's proposed Water Management Plan should be approved and LCRA's applications to amend Certificates of Adjudication Nos. 14-5478 and 14-5482 should be granted.

NOW, THEREFORE, BE IT ORDERED BY THE TEXAS WATER COMMISSION  
THAT:

1. LCRA's proposed Water Management Plan is approved with the following conditions:
  - a. The Water Management Plan shall be subject to the continuing right of supervision of the Commission, and the Commission, on its own motion, may reconsider any element of the plan at any time in the future.
  - b. LCRA's responsibility and authority under the Water Management Plan is limited to operational control of the Highland Lakes and LCRA's facilities downstream, and is limited by the terms of this Order.
  - c. LCRA's responsibility and authority under the Water Management Plan is subject to and shall not conflict with the authority of any watermaster operation the Commission may establish on the Colorado River.
  - d. LCRA shall make available to the Commission all real-time, historical or allocated streamflow data collected by LCRA.

- e. LCRA shall supply interruptible water, in accordance with the provisions and conditions specified in the Final Judgement and Decree, to any downstream water right with a priority date junior to December 1, 1900 and senior to November 1, 1987 that authorizes the diversion of not more than 3000 acre-feet of water per year. Priority shall be given to these water rights in the same manner that LCRA allocates water to the major irrigation operations downstream (Lakeside, Gulf Coast, Garwood and Pierce Ranch).
- f. All sales, agreements or LCRA Board commitments for the use of water in or from the Highland Lakes shall be submitted to the Commission within 45 days of the effective date of the document.
- g. LCRA shall submit a drought contingency plan within one year from the date the Commission signs this order approving the Water Management Plan. Such plan shall be subject to the review and approval of the Commission.
- h. LCRA shall allocate 25,000 acre-feet per annum of its firm water supply to supplement and maintain a minimum monthly mean flow of 200 cfs throughout the lower Colorado River measured at the USGS gage at Bastrop for instream flow purposes and a minimum monthly mean flow of 200 cfs, a minimum seasonal mean flow of 375 cfs and a minimum annual flow of 272,121 acre-feet measured at the USGS gage at Bay City for freshwater inflow to the Lavaca-Tres Palacios estuarine system.
- i. Prior to any diversion of surface water for recharge purposes, LCRA shall obtain the necessary authorizations from the Commission.
- j. LCRA shall prepare and submit to the Commission, on or before March 1 of each year beginning with March 1, 1990, a report which documents compliance with the approved Water Management Plan and any special conditions thereto during the previous year. Such report shall be in a form approved by the Executive Director.
- k. After the instream study by LCRA and TPWD is completed, but in any event no later than March, 1992, LCRA will submit an application to amend its Water Management Plan to reflect the results of the instream flow studies and the studies and evaluations referenced in Findings of fact #73, 74, & 75 above. LCRA shall do all things necessary to ensure that such application is administratively and technically complete within 6 months of submission. The Commission agrees to hold a hearing within one year of the date of LCRA's submission to

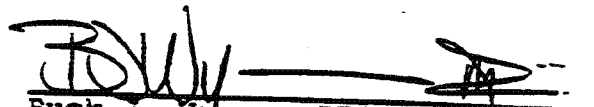
consider the amendments of the Plan, or, if the studies are not complete, to determine why such studies are not complete.

1. After completion of the TWDB and TPWD study on freshwater inflows into the bays and estuaries, as applicable to the Lavaca-Tres Palacios Estuary, and in any event no later than March, 1993, LCRA will submit an application to amend its Water Management Plan to reflect the results of the bays/estuary study. LCRA shall do all things necessary to ensure that such application is administratively and technically complete within 6 months of submission. The Commission agrees to hold a hearing within one year of the date of LCRA's submission to consider the amendments of the Plan, or, if the studies are not complete, to determine why such studies are not complete.
  - m. The combined firm yield as found by the Commission in this Order is subject to adjustment and refinement from time to time as additional studies and simulations are developed that more accurately reflect assumptions and operations as required by law.
  - n. The Commission retains jurisdiction to resolve any and all disputes regarding the allocation of stored water from Lakes Travis and Buchanan, notwithstanding the procedures and guidelines set forth in the Water Management Plan.
2. LCRA's applications to amend Certificates of Adjudication Nos. 14-5478 and 14-5482 are granted with the following conditions:
  - a. LCRA's certificates of adjudication shall reflect the combined annual firm yield of Lakes Travis and Buchanan to be as found by the Commission in this Order, and as may be modified by the Commission from time to time.
  - b. For purposes of perfection, LCRA's authorization to divert, release or use water for recreation purposes is limited to that quantity of water actually sold for that purpose whether used in, or released, or diverted from Lakes Buchanan and Travis.
3. The Chief Clerk of the Texas Water Commission forward a copy of this Order, subject to the filing of motions for rehearing, to all parties.
4. If any provision, sentence, clause or phrase of this Order is for any reason held to be invalid, the invalidity of any portion shall not affect the validity of the remaining portions of the Order.

5. Nothing in the Water Management Plan or this Order shall be construed to impair, or to authorize LCRA or any other person or entity to impair, senior or superior water rights in the Colorado River Basin.

Signed this 20th day of September, 1989.

TEXAS WATER COMMISSION

  
Buck J. Wynne, III, Chairman

(SEAL)

  
Brenda W. Foster, Chief Clerk

Appendix C-2  
Order approving LCRA's Drought Management Plan  
Dated December 23, 1991



THE STATE OF TEXAS  
COUNTY OF TRAVIS  
TEXAS WATER COMMISSION



MISSIO, certify that this is a true and correct copy of a Texas Water Commission document, the original of which is filed in the permanent records of the Commission.  
Given under my hand and the seal of office on  
JAN 6 1992

*Glenn A. Vasequez*  
Glenn A. Vasequez, Chief Clerk  
BEFORE THE  
TEXAS WATER COMMISSION

CONSIDERATION OF THE  
LOWER COLORADO RIVER  
AUTHORITY'S DROUGHT  
MANAGEMENT PLAN

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ORDER APPROVING LOWER COLORADO  
RIVER AUTHORITY'S DROUGHT MANAGEMENT PLAN

On the 18th day of December, 1991, the Texas Water Commission ("Commission") held a public hearing to consider the Lower Colorado River Authority's ("LCRA") proposed Drought Management Plan. At the hearing, the following were named as parties: the Lower Colorado River Authority; the Texas Parks and Wildlife Department ("TPWD"); the City of Austin; Garwood Irrigation Company; the Sierra Club, Lone Star Chapter; the Matagorda County Water Council; Houston Lighting and Power Company as Project Manager for the South Texas Project; the Executive Director of the Texas Water Commission; and the Public Interest Counsel of the Texas Water Commission. Having considered the proposed agreed order of the parties, the Commission makes the following Findings of Fact and Conclusions of Law:

FINDINGS OF FACT

1. Notice of the public hearing was published on October 10, 1991 in the Blanco County Record Courier, a newspaper regularly published and generally circulated in Blanco County, Texas; October 9, 1991 in the Austin American-Statesman, a newspaper regularly published and generally circulated in Travis County, Texas; on October 9, 1991 in the Colorado County Citizen, a newspaper regularly published and generally circulated in Colorado County, Texas; on October 10, 1991 in the San Saba News and Star, a newspaper regularly published and generally circulated in San Saba County, Texas; on October 10, 1991 in the Llano News, a newspaper regularly published and generally circulated in Llano County, Texas; on October 10, 1991 in the Highlander, a newspaper regularly published and generally circulated in Burnet County, Texas; on October 10, 1991 in the Bay City Daily Tribune, a newspaper regularly published and generally circulated in Matagorda County, Texas; on October 8, 1991 in the Fayette County Record, a newspaper regularly published and generally circulated in Fayette County, Texas; on October 5, 1991 in the El Campo Leader-News, a newspaper regularly published and generally circulated in Wharton County, Texas; and on October 7, 1991 in the Bastrop Advertiser, a newspaper regularly published and generally circulated in Bastrop County, Texas. These ten counties are

the only counties in which persons reside who may be affected by action taken as result of the hearing. Said notice was published not less than thirty (30) days before the date of the hearing.

2. On September 26, 1991, notice of the public hearing was sent by first-class mail to persons who may be affected by action taken as a result of the hearing and to each person as required by law.
3. LCRA is requesting approval of its Drought Management Plan for the Lower Colorado River, Colorado River Basin, in accordance with the Commission's September 7, 1989 Order approving LCRA's Water Management Plan and amending Certificates of Adjudication Nos. 14-5478 and 14-5482. LCRA's Water Management Plan was developed and submitted by LCRA in accordance with the Final Judgment and Decree entered by the court in Cause No. 115,414 A-1, 264th Judicial District, In Re: The Exceptions of the Lower Colorado River Authority and the City of Austin to the Adjudication of Water Rights in the Lower Colorado River Segment of the Colorado River Basin.
4. LCRA's proposed Drought Management Plan was filed with the Commission on October 19, 1990.
5. LCRA's procedures and guidelines set forth in the Water Management Plan and the Drought Management Plan for the allocation of firm water and interruptible water supplies are acceptable as conditioned by the provisions of this Agreed Order and with the understanding that the allocation procedures may be amended by the Commission at a later time for any justifiable reason including, but not limited to, an amendment to reflect the results of the instream flow and bay and estuary studies; provided, however, that the Commission shall retain jurisdiction to resolve all disputes regarding allocation of stored water that may arise in the future.
6. The priorities in LCRA's Water Management Plan and Drought Management Plan for interruptible water are subject to change after the completion of the studies on the instream flows and bays and estuaries required by conditions (k) and (l) of the September 7, 1989 Order.
7. Because of the water-availability and water-demand conditions that presently exist, it appears that 25,000 acre-feet of stored water per year probably will be adequate in the near future to firm up the minimum flows for instream flows and bays and estuaries set forth in condition (h) of the Commission's September 7, 1989 Order. Pursuant to conditions (k) and (l) of the Commission's September 7, 1989 Order, LCRA is required to submit applications to amend the Water Management Plan and the Drought Management Plan following completion of studies on instream flows and bays and estuaries

required by March 1992, and March 1993, respectively. Accordingly, it is unnecessary for the Commission to determine at this time whether the Commission, by its September 7, 1989 Order or otherwise, intended to give LCRA the authority or impose upon it the obligation to release more than 25,000 acre-feet of stored water in any one year to firm up those minimum flows.

8. Based on available studies and information, it is uncertain whether LCRA's proposed plan to begin curtailment of interruptible stored water supplies at a January 1 trigger level of 1.4 million acre-feet of water in storage is appropriate, in that it may provide more protection to firm supplies of stored water than is necessary. However, because of the water-availability and water-demand conditions that presently exist, it is likely that such level will not be reached in the near future. Accordingly, it is unnecessary for the Commission to determine at this time whether, or to what extent, such trigger level provides more protection to firm supplies than is necessary.
9. LCRA asserts that nothing in the Drought Management Plan should be construed to modify or impair in any way any contractual obligation of LCRA to supply water.

#### CONCLUSIONS OF LAW

1. The public hearing was held under the authority and in accordance with Chapter 11 of the Texas Water Code, as amended and the Texas Water Commission Permanent Rules.
2. The Texas Water Commission has jurisdiction to consider and take action on LCRA's proposed Drought Management Plan.
3. It is unnecessary at this time to determine whether the Commission, by its September 7, 1989 Order or otherwise intended to give LCRA the authority or impose upon it the obligation to release more than 25,000 acre-feet of stored water in any one year for instream flows and bays and estuaries. By approving the Drought Management Plan and entering this Order, the Commission specifically is not deciding these issues.

NOW, THEREFORE, BE IT ORDERED BY THE TEXAS WATER COMMISSION.  
THAT:

1. LCRA's proposed Drought Management Plan is approved with the following conditions:
  - a. LCRA's Drought Management Plan is subject to LCRA's Water Management Plan and all findings, conclusions and conditions contained within the Commission's September 7, 1989 Order approving the Water

Management Plan including, without limitation, any findings, conclusions and conditions contained in this Order that are also contained within the September 7, 1989 Order.

- b. The Drought Management Plan shall be subject to the continuing right of supervision of the Commission, and the Commission, on its own motion, may reconsider any element of the plan at any time in the future.
- c. LCRA's responsibility and authority under the Drought Management Plan is limited to operational control of the Highland Lakes and LCRA's facilities downstream, and is limited by the terms of this Order and the Commission's September 7, 1989 Order.
- d. LCRA is required to pass all inflows to the Highland Lakes to the extent necessary to satisfy the demands of all downstream senior rights, and nothing in the Drought Management Plan or this order shall be construed to modify or impair this obligation.
- e. LCRA shall prepare and submit to the Commission, on or before March 1 of each year beginning with March 1, 1992, a report which documents compliance with the approved Drought Management Plan and any special conditions thereto during the previous year. Such report shall be in a form approved by the Executive Director.
- f. After the instream study by LCRA and TFWD is completed, but in any event not later than March, 1992, LCRA shall submit an application to amend its Water Management Plan and its Drought Management Plan to reflect the results of the instream flow studies and the studies and evaluations referenced in Findings of Fact Nos. 73, 74, and 75 of the Commission's September 7, 1989 Order. Such application shall also propose conditions for implementing or cancelling the declaration of a drought to be worse than the drought of record. LCRA shall do all things necessary to ensure that such application is administratively and technically complete within six months of submission. The Commission agrees to hold a hearing within one year of the date of LCRA's submission to consider the amendments of the Plans, or if the studies are not complete, to determine why such studies are not complete.

- g. After completion of the Texas Water Development Board ("TWDB") and TPWD study on freshwater inflows into the bays and estuaries, as applicable to the Lavaca-Tres Palacios Estuary, and in any event not later than March, 1993, LCRA shall submit an application to amend its Water Management Plan and its Drought Management Plan to reflect the results of the bays/estuary study. LCRA shall do all things necessary to ensure that such application is administratively and technically complete within six months of submission. The Commission agrees to hold a hearing within one year of the date of LCRA's submission to consider the amendments of the Plans, or, if the studies are not complete, to determine why such studies are not complete.
  - h. The combined firm yield as found by the Commission in Finding of Fact No. 47 of its September 7, 1989 Order is subject to adjustment and refinement from time to time as additional studies and simulations are developed that more accurately reflect assumptions and operations as required by law.
  - i. LCRA's proposed plan to begin curtailment of interruptible stored water at a January 1 trigger level of 1.4 million acre-feet of water in storage, and other aspects of LCRA's proposed curtailment plan, are subject to adjustment from time to time as additional studies and simulations may be developed that more accurately address the need to curtail interruptible supplies.
  - j. The Commission retains jurisdiction to resolve any and all disputes regarding the allocation of stored water from Lakes Travis and Buchanan, notwithstanding the procedures and guidelines set forth in the Water Management Plan and/or the Drought Management Plan.
2. The Chief Clerk of the Texas Water Commission shall forward a copy of this Order subject to the filing of motions for rehearing, to all parties.
  3. If any provision, sentence, clause or phrase of this Order is for any reason held to be invalid, the invalidity of any portion shall not affect the validity of the remaining portions of the Order.
  4. Nothing in the Drought Management Plan or this Order shall be construed to impair, or to authorize LCRA or any other person or entity to impair, senior or superior water rights in the Colorado River Basin.

Issued: DEC 23 1991

TEXAS WATER COMMISSION

  
John Hall, Chairman

ATTEST:

  
Gloria A. Vasquez, Chief Clerk

Appendix C-3  
Agreed Order Approving Amendments to  
LCRA's Water Management and Drought Management Plan,  
Dated December 18, 1992

THE STATE OF TEXAS  
COUNTY COMMISSION  
TEXAS WATER COMMISSION



I hereby certify that this is a true and correct copy of a  
Texas Water Commission document which is filed in th  
permanent records of the Commission.  
Given under my hand and the seal of office on

JAN 11 1999

CONSIDERATION OF THE  
LOWER COLORADO RIVER AUTHORITY  
APPLICATION TO AMEND ITS  
WATER MANAGEMENT PLAN AND  
DROUGHT MANAGEMENT PLAN

BEFORE THE Gloria A. Vasquez, Chief Clerk  
TEXAS WATER COMMISSION

AGREED ORDER APPROVING AMENDMENTS TO LOWER COLORADO  
RIVER AUTHORITY'S WATER MANAGEMENT  
PLAN AND DROUGHT MANAGEMENT PLAN

On the 2nd day of December, 1992, the Texas Water Commission  
("Commission") considered the Lower Colorado River Authority's  
("LCRA") application to amend its Water Management Plan and Drought  
Management Plan, and having heard evidence and arguments concerning  
the proposed order, the Commission makes the following Findings of  
Fact and Conclusions of Law:

Findings of Fact

- 1) Notice of the public hearing was published on September 3,  
1992, in the Johnson City Record-Courier, a newspaper  
regularly published and generally circulated in Blanco County,  
Texas; on August 23, 1992 in the Austin American-Statesman, a  
newspaper regularly published and generally circulated in  
Travis County, Texas; on August 26, 1992 in the Colorado  
County Citizen, a newspaper regularly published and generally  
circulated in Colorado County, Texas; on August 27, 1992 in  
the San Saba News & Star, a newspaper regularly published and  
generally circulated in San Saba County, Texas; on September  
3, 1992 in the Llano News, a newspaper regularly published and  
generally circulated in Llano County, Texas; on August 27,  
1992 in the Marble Falls Highlander, a newspaper regularly  
published and generally circulated in Burnet County, Texas; on

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August 25, 1992 in the Bay City Daily Tribune, a newspaper regularly published and generally circulated in Matagorda County, Texas; on August 25, 1992 in the Fayette County Record, a newspaper regularly published and generally circulated in Fayette County, Texas; on August 22, 1992 in the El Campo Leader-News, a newspaper regularly published and generally circulated in Wharton County, Texas; and on August 27, 1992 in the Bastrop Advertiser, a newspaper regularly published and generally circulated in Bastrop County, Texas. These ten counties are the only counties in which persons reside who may be affected by action taken as a result of the hearing. Said notice was published not less than thirty (30) days before the date of the hearing.

- 2) On August 11, 1992, notice of the public hearing was sent by first-class mail to persons who may be affected by action taken as a result of the hearing and to each person as required by law.
- 3) LCRA's Application to Amend its Water Management Plan and Drought Management Plan ("Application") was received by the Commission on May 29, 1992 and July 15, 1992.
- 4) LCRA's Application was accepted by the Commission as administratively complete on July 23, 1992.
- 5) The Lake Travis Chamber of Commerce requested LCRA to amend its Water Management Plan to change the trigger level of Lake Travis from 660 feet msl to 667 feet msl; to limit new interruptible water contracts to the volume of water saved in the rice irrigation conservation program; and to revise the description of the lake's economy.
- 6) In response to the request by the Lake Travis Chamber of Commerce, LCRA proposes to amend the Water Management Plan to

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eliminate the trigger levels of 660 feet msl for Lake Travis and 1012 feet msl for Lake Buchanan; to limit sales of interruptible stored water, other than for the four major irrigation districts' Conservation Base or Priority Allocation acreage, based on the projected volume of water in Lakes Buchanan and Travis as of January 1, of each year. No such sales would occur if either lake is less than 94% of its maximum conservation capacity. If both lakes are projected to be at their maximum conservation capacity on January 1, then such interruptible water sales would be limited to a total of 80,000 acre-feet for that year. For projected lake volumes between 94% and 100% of the conservation capacity, such interruptible water sales would be limited proportionately, based on the storage reservoir with the lowest projected percentage of capacity on January 1. LCRA also proposes to increase the Conservation Base acreage for the Gulf Coast Irrigation Division from 37,000 acres to 50,000 acres and set the Priority Allocation acreage for Pierce Ranch at 10,476 acres.

- 7) LCRA's Drought Management Plan presently allows for the cancellation of curtailments of interruptible stored water to the four major irrigation districts if the combined storage of Lakes Buchanan and Travis is at least 1.4 million acre-feet on July 1.
- 8) LCRA proposes to amend LCRA's Drought Management Plan to provide that curtailment of interruptible stored water for the four major irrigation districts may be cancelled at any time during the year prior to July 31. The criteria for cancelling the curtailments is that the combined storage of Lakes Buchanan and Travis is projected to be equal to or greater than 1.4 million acre-feet of water anytime in July.

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- 9) LCRA's Water Management Plan presently allows LCRA to reserve 50,000 acre-feet of the remaining combined firm yield of Lakes Buchanan and Travis for future uses under LCRA's certificates of adjudication. This reservation will be until water supply and demand assessments for LCRA's 10-county statutory district are completed or within three years, whichever is sooner.
- 10) LCRA has completed the water supply and demand assessments for its 10-county statutory district. The results of these studies indicate new surface water demands of approximately 39,000 acre-feet annually by the year 2013.
- 11) LCRA is presently in the process of updating these water supply and demand assessments to include the results of the 1990 federal census. To allow LCRA additional time to complete such updated assessments, it is reasonable to allow LCRA to continue to reserve 50,000 acre-feet of the remaining combined firm yield of Lakes Buchanan and Travis for future uses under its certificate of adjudication, through December 31, 1993.
- 12) The Commission's September 7, 1989 Order approving LCRA's Water Management Plan, directed LCRA in accordance with Findings of Fact No. 73, 74, and 75, to reference and summarize information on point and non-point pollution sources and loading on the Colorado River, identify new data needed to determine water quality effects on revision of the minimum flow schedule, and evaluate potential problems associated with anoxic hypolimnetic releases from reservoirs and the potential for related fish kills due to resulting low dissolved oxygen levels downstream. LCRA has completed these studies and evaluations. The instream flow schedule set forth in this Agreed Order was developed in response to those studies and evaluations.

- 13) The Commission's December 23, 1991 Order approving LCRA's Drought Management Plan directed LCRA to propose conditions for implementing and cancelling a declaration of a drought worse than the drought of record.
- 14) LCRA proposes that its Drought Management Plan be amended to provide that the LCRA Board of Directors will declare a drought worse than the drought of record when the following three conditions are simultaneously met:
- (a) drought at least 36 consecutive months (36 months since both Lakes Buchanan and Travis were last full); and
  - (b) the cumulative inflow deficit since the beginning of the drought exceeds the envelope curve for cumulative inflow deficits by at least 5% for six consecutive months; and
  - (c) the combined storage of Lakes Buchanan and Travis is less than 600,000 acre-feet.

The LCRA Board of Directors will cancel such a declaration if any of the following conditions are met:

- (d) the cumulative inflow deficit since the beginning of the drought is less than the envelope curve for cumulative inflow deficits by at least 5% for six consecutive months; or
  - (e) the combined storage in Lakes Buchanan and Travis is greater than 1.4 million acre-feet of water.
- 15) LCRA and TPWD have completed their instream flow needs study for the lower Colorado River. Based upon this study LCRA proposes that LCRA's Water Management Plan and Drought Management Plan be amended as follows:

- 5 -

- (a) LCRA's existing commitment of 25,000 acre-feet of firm yield water supply, to supplement and maintain instream flows, be increased to an average of 31,800 acre-feet annually during any 10 consecutive year period.
  - (b) LCRA will maintain the daily river flows below the City of Austin's Longhorn Dam at no less than the subsistence/critical flows in all years.
  - (c) When the combined storage of Lakes Buchanan and Travis is projected to be above 1.4 million acre-feet of water on January 1, or if interruptible stored water curtailments are cancelled, LCRA will maintain during that calendar year or portion thereof target flows to the extent of inflows each day to the Highland Lakes as measured by upstream gages.
  - (d) Interruptible water contracts will be totally cutoff when the minimum January 1 storage of Lakes Buchanan and Travis is at or below 325,000 acre-feet of water.
- 16) The schedule of instream flows for the Colorado River downstream of the City of Austin's Longhorn Dam is as follows:

Subsistence/  
Critical Flows (cfs)      Target Flows (cfs)

Month	Austin	Bastrop	Bastrop	Eagle Lake	Egypt
January	46 <sup>c</sup>	120	370	300	240
February	46 <sup>c</sup>	120	430	340	280
March	46 <sup>c</sup>	500 <sup>b</sup>	560	500 <sup>a</sup>	360
April	46 <sup>c</sup>	500 <sup>b</sup>	600	500 <sup>a</sup>	390
May	46 <sup>c</sup>	500 <sup>b</sup>	1030	820	670
June	46 <sup>c</sup>	120	830	660	540
July	46 <sup>c</sup>	120	370	300	240
August	46 <sup>c</sup>	120	240	200	160
September	46 <sup>c</sup>	120	400	320	260
October	46 <sup>c</sup>	120	470	380	310
November	46 <sup>c</sup>	120	370	290	240
December	46 <sup>c</sup>	120	340	270	220

\* Since target flow at Eagle Lake (based on overall community habitat availability) were insufficient to meet Blue Sucker (*Cyprinostomus elongatus*) spawning requirements during March and April target flows were superseded by critical flow recommendations for this reach.

<sup>b</sup> This flow should be maintained for a continuous period of not less than six weeks during these months. A flow of 120 cfs will be maintained on all days not within the six week period.

<sup>c</sup> LCRA will maintain a mean daily flow of 100 cfs at the Austin gage at all times, to the extent of inflows each day to the Highland Lakes as measured by upstream gages, until the combined storage of Lakes Buchanan and Travis reaches 1.4 million acre-feet of water. A mean daily flow of 75 cfs, to the extent of inflows each day to the Highland Lakes as measured by upstream gages, will

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then be maintained until the combined storage of Lakes Buchanan and Travis reaches 1.0 million acre-feet of water. When the combined storage of Lakes Buchanan and Travis is reduced below 1.0 million acre-feet of water, then a subsistence/critical flow of 46 cfs will be maintained at all times regardless of inflows.

In addition, if the subsistence/critical flow of 46 cfs should occur for an extended period of time, then operational releases will be made by LCRA to temporarily alleviate the subsistence/critical flow conditions. Specifically, should the flow at the Austin gage be below a 65 cfs daily average for a period of 21 consecutive days, LCRA will make operational releases from storage sufficient to maintain daily average flow at the Austin gage of at least 200 cfs for two consecutive days. If this operational release condition persists for three consecutive cycles (69 days), then a minimum average daily flow of at least 75 cfs will be maintained for the next 30 days.

- 17) The priorities in LCRA's Water Management Plan and Drought Management Plan for use of interruptible water are subject to change after the completion of the studies on bay and estuary inflows referenced in condition (1) of the September 7, 1989 Order Approving LCRA's Water Management Plan.
- 18) Until such time that the Commission amends the requirement for freshwater inflows into the Lavaca Tres-Palacios Estuary as a result of the completion of the Texas Water Development Board and Texas Parks and Wildlife Department study on freshwater inflows LCRA shall continue to maintain a minimum monthly mean flow of 200 cfs, a minimum seasonal mean flow of 375 cfs and a minimum annual flow of 272,121 acre-feet measured at the USGS gage at Bay City for freshwater inflow to the Lavaca-Tres Palacios estuarine system.

Conclusions of Law

- 1) The Commission considered this Agreed Order under the authority and in accordance with Chapter 11 of the Texas Water Code, as amended and 31 Texas Administrative Code ("TAC") § 295 et. al.
- 2) The Texas Water Commission has jurisdiction to consider and take action on LCRA's application to amend its Water Management Plan and Drought Management Plan.

NOW, THEREFORE, BE IT ORDERED BY THE TEXAS WATER COMMISSION THAT:

- 1) LCRA's proposed amended Water Management Plan and Drought Management Plan are approved with the following conditions:
  - a) LCRA's amended Water Management Plan is subject to all findings, conclusions, and conditions contained in the Commission's September 7, 1989 Order approving the Plan, except to the extent specifically provided otherwise by this Agreed Order.
  - b) LCRA's amended Drought Management Plan is subject to all findings, conclusions, and conditions, contained in the Commission's December 23, 1991 Order approving the Plan, except to the extent specifically provided otherwise by this Agreed Order.
  - c) Nothing in this Agreed Order shall be construed to impair any party's right to contest or seek clarification of, at anytime, any issue in connection with LCRA's Water Management Plan and Drought Management Plan. The Commission takes notice that the Sierra Club has contested the issue of priority of use of interruptible water and that contest has been remanded for hearing.

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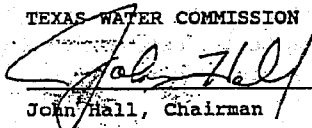


Nothing in this Agreed Order shall be construed as deciding that issue. Furthermore, if in that hearing, the priority of use for interruptible water, as it relates to instream flows, is determined by the Commission to be different than that set forth in those Plans, any party shall have the express right to reopen the issue of instream flow requirements by submitting a written request for hearing to the Office of Hearings Examiners.

- 2) The Chief Clerk of the Texas Water Commission shall forward a copy of this Agreed Order subject to the filing of motions for rehearing, to all parties.
- 3) If any part of this Agreed Order is for any reason held to be invalid, the invalidity of any portion shall not affect the validity of the remainder of the Agreed Order.
- 4) Nothing in LCRA's Water Management Plan and Drought Management Plan or this Agreed Order shall be construed to impair, or to authorize LCRA or any other person or entity to impair, senior or superior water rights in the Colorado River Basin.

ISSUED: DEC 18 1992

TEXAS WATER COMMISSION

  
John Hall, Chairman

ATTEST:

  
Gloria A. Vasquez, Chief Clerk

BW12/C5

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Appendix C-4  
Agreed Order Approving Amendments to  
LCRA's Water Management and Drought Management Plan,  
Dated March 1, 1999

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION



THE STATE OF TEXAS  
COUNTY OF TRAVIS  
I hereby certify that this is a true and correct copy of a Texas Natural  
Resource Conservation Commission document, which is filed in the  
permanent records of the Commission.  
Given under my hand and the seal of office on

*La Donna Combs* MAR 04 1999

DOCKET NO. 98-1387-WR

La Donna Combs, Chief Clerk  
Texas Natural Resource  
Conservation Commission

CONSIDERATION OF THE  
LOWER COLORADO RIVER AUTHORITY'S  
APPLICATION TO AMEND ITS WATER  
MANAGEMENT PLAN INCLUDING ITS  
DROUGHT MANAGEMENT  
PLAN

§  
§  
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BEFORE THE  
TEXAS NATURAL RESOURCE  
CONSERVATION COMMISSION

ORDER APPROVING AMENDMENTS TO LOWER COLORADO  
RIVER AUTHORITY'S WATER MANAGEMENT PLAN  
INCLUDING ITS DROUGHT MANAGEMENT PLAN

On the 24<sup>th</sup> day of February, 1999, the Texas Natural Resource Conservation Commission  
("Commission") considered the Lower Colorado River Authority's ("LCRA") application to amend  
its Water Management Plan including its amended Drought Management Plan ("WMP"), and having  
heard evidence and arguments concerning the proposed order, the Commission makes the following  
Findings of Fact and Conclusions of Law:

Findings of Fact

- 1) Notice of the public comment meeting and notice of the Commission's Agenda Date on  
proposed amendments to LCRA's WMP was published on December 17, 1998, in the  
Johnson City Record-Courier, a newspaper regularly published and generally circulated in  
Blanco County, Texas; on December 18, 1998 in the Austin American-Statesman, a  
newspaper regularly published and generally circulated in Travis County, Texas; on  
December 23, 1998 in the Colorado County Citizen, a newspaper regularly published and

generally circulated in Colorado County, Texas; on December 17, 1998 in the San Saba News & Star, a newspaper regularly published and generally circulated in San Saba County, Texas; on December 17 and 24, 1998 in the Llano News, a newspaper regularly published and generally circulated in Llano County, Texas; on December 18, 1998 in the Marble Falls Highlander, a newspaper regularly published and generally circulated in Burnet County, Texas; on December 20, 1998 in the Bay City Daily Tribune, a newspaper regularly published and generally circulated in Matagorda County, Texas; on December 18, 1998 in the Fayette County Record, a newspaper regularly published and generally circulated in Fayette County, Texas; on December 19, 1998 in the El Campo Leader-News, a newspaper regularly published and generally circulated in Wharton County, Texas; and on December 19, 1998 in the Bastrop Advertiser, a newspaper regularly published and generally circulated in Bastrop County, Texas. These ten counties are the only counties in which persons reside who may be affected by action taken by the Commission on the proposal amendments. Said notice was published not less than thirty (30) days before the Commission's Agenda Date.

- 2) On December 16, 1998, notice of the public comment meeting and the Commission's Agenda Date was sent by first-class mail to persons who may be affected by action taken by the Commission and to each person as required by law.
- 3) By Commission order of September 20, 1989, the Commission conditionally approved LCRA's WMP. By Commission order of December 23, 1991, the Commission conditionally approved LCRA's Drought Management Plan, which is included as part of LCRA's WMP. Amendments to the plans were conditionally approved by Commission agreed order of December 18, 1992. These prior orders of the Commission required LCRA to submit an application to amend its WMP to reflect the results of a bay/estuary study to be completed

by Texas Water Development Board (TWDB) and Texas Parks & Wildlife Department (TPWD). In 1993, LCRA, TWDB, TPWD, and TNRCC entered into a cooperative agreement to complete the study. The study was completed in 1997 and LCRA filed its proposed amendments to the WMP to reflect the results of the study.

- 4) LCRA's application to Amend its WMP including its Drought Management Plan ("Application") was received by the Commission on May 29, 1997; addenda were received December 29, 1997 and September 29, 1998.
- 5) LCRA's Application was accepted by the Commission as administratively complete on November 13, 1998.
- 6) On January 5, 1999 the Commission held a public comment meeting. One person presented oral comments, which were not in opposition to the proposed amendments. No written public comments were provided by any person.
- 7) No protests and no requests for a contested case hearing have been filed with the Commission regarding the proposed amendments.
- 8) LCRA's WMP currently requires LCRA to meet an interim freshwater inflow need to the Lavaca-Tres Palacios Estuary, also known as the Lavaca-Colorado Estuary or the Matagorda Bay System of 272,000 acre-feet annually, as measured at the USGS Bay City gage.
- 9) LCRA's proposed amendments to the WMP would require LCRA to:
  - (a) release monthly inflows otherwise available for storage in the Highland Lakes to meet monthly target freshwater inflow needs of the Matagorda Bay System totaling 1.03 million acre-feet per year, as measured at the USGS Bay City gage, if January 1 storage levels in Lakes Travis and Buchanan combined is greater than 1.7 million acre-feet;

- (b) release monthly inflows otherwise available for storage in the Highland Lakes to meet monthly critical freshwater inflow needs of the Matagorda Bay System totaling 171,100 acre-feet per year, as measured at the USGS Bay City gage, in all years; and
  - (c) stored water releases will be a combination of firm and interruptible stored water supplies. Firm water will be supplied in years when the four major irrigation districts' stored water supplies are curtailed. Interruptible stored water will be supplied in all other years.
- 10) LCRA's WMP currently requires LCRA to use up to a maximum of 318,000 acre-feet of firm stored water over any ten (10) consecutive years for instream flows and freshwater inflow needs of the Matagorda Bay System. The WMP currently provides for a total commitment of 31,800 acre-feet per year from the Combined Firm Yield of Lakes Travis and Buchanan for instream flows and freshwater inflow needs of the Matagorda Bay System.
- 11) LCRA's proposed amendments to the WMP are as follows:
- (a) total commitments of the Combined Firm Yield from the Highland Lakes for instream flow maintenance will be an average of 12,860 acre-feet per year, with a maximum of 36,720 acre-feet in any one year; 58,700 acre-feet in any two consecutive years; 76,800 acre-feet in any three or four consecutive years; 106,100 acre-feet in any five consecutive years and 128,600 acre-feet in any six to ten consecutive years. Total commitments of the Combined Firm Yield from the Highland Lakes for freshwater inflows to the Matagorda Bay System will be an average of 3,090 acre-feet per year, with a maximum of 11,200 acre-feet in any one year; 19,700 in any two consecutive years; 24,200 acre-feet in any three or four consecutive years; 28,200 acre-feet in any five consecutive years and 30,900 acre-

feet in any six to ten consecutive years. The total firm stored water commitment for both purposes will be an average of 15,950 acre-feet per year. Estimated interruptible stored water supplied during the critical drought for both purposes will be an average of an additional 40,060 acre-feet per year.

- 12) Currently under the WMP the LCRA Board of Directors will declare a drought worse than the drought of record when three (3) conditions are simultaneously met. First, a drought of at least 36 consecutive months since both Lakes Travis and Buchanan were last full. Second, the cumulative inflow deficit since the beginning of the drought exceeds the envelope curve for cumulative inflow deficits by at least 5% for six consecutive months. Third, the combined storage of Lakes Travis and Buchanan is less than 600,000 acre-feet.
- 13) Because of the severity of the 1996 drought LCRA proposes the following amendments to the WMP:
  - (a) reduce the 36 month minimum to 24 months;
  - (b) curtailments of interruptible stored water due solely to the declaration of a drought to be worse than drought of record of less than 36 months in duration is only effective on the following January 1 or July 31, whichever occurs first following the declaration by the LCRA Board of Directors. Droughts more than 36 months in length have no restrictions as to when supply reductions can be implemented;
  - (c) prior to implementing curtailment of firm water supplies during droughts worse than drought of record, LCRA will meet with its firm water customers and develop a specific stored water curtailment plan approved by the LCRA Board of Directors and the Commission.

- (d) Such a declaration will be canceled when the combined storage in Lakes Travis and Buchanan is greater than 1.1 million acre-feet of water, which is simply the recommended threshold for curtailment of interruptible water during a repetition of the drought of record. Prior to declaring a drought worse than the drought of record, the LCRA will re-evaluate this threshold level to determine if a more accurate cancellation storage level in lieu of 1.1 million acre-feet can be determined.
- 14) LCRA's WMP currently states that the storage level for initial curtailment of interruptible stored water for the four (4) major irrigation districts (Lakeside, Gulf Coast, Garwood and Pierce Ranch) will commence when the combined storage in Lakes Travis and Buchanan is less than or equal to 1.4 million acre-feet projected on January 1.
- 15) LCRA's proposed amendment reduces the combined storage level from 1.4 to 1.1 million acre-feet projected on January 1.
- 16) LCRA's WMP currently provides that the allocation of interruptible stored water to users other than the four (4) major irrigation districts is made annually based on projected January 1 storage levels in Lakes Travis and Buchanan taken separately. The maximum supply of interruptible stored water available currently under the WMP is 80,000 acre-feet per year.
- 17) LCRA's proposed amendments will change the allocation of interruptible stored water to users other than the four (4) major irrigation districts to a semiannual allocation as follows:
- (a) the supply for January through June is based on January 1 storage levels in Lakes Travis and Buchanan taken separately;
  - (b) the supply for July through December is based on the minimum of the maximum storage levels in April, May and June in Lakes Travis and Buchanan taken separately.



- (c) maximum supply available under LCRA's proposed amendments is 30,000 acre-feet per year.
- 18) LCRA's WMP currently provides that the LCRA Board of Directors has committed to reserving 50,000 acre feet of the remaining Combined Firm Yield of the Highland Lakes through December 31, 1993 for future uses within LCRA's service area.
- 19) LCRA's proposed amendment is to reserve 50,000 acre-feet of water of the remaining Combined Firm Yield of the Highland Lakes for future uses within LCRA's service area indefinitely, as reflected in current LCRA Board of Directors policy.
- 20) On March 29, 1996 the Commission issued its Order severing a portion of the water rights authorized by Certificate No. 14-2564 (Hudson et ux) and combining it with all of the water rights authorized by LCRA's Certificate No. 14-5478, (Lake Buchanan) as amended. Certificate No. 14-5478C was issued to LCRA on the same date and authorizes LCRA to transfer downstream 532 acre-feet of water for use by LCRA out of Lake Buchanan with consumption use limited to 500 acre-feet per year.
- 21) Because the priority date of the water severed from Certificate No. 14-2564 and purchased by LCRA is 1929, senior to the 1938 Lake Buchanan priority date, LCRA is requesting that the WMP be amended to reflect an increase of 500 acre-feet in the Combined Firm Yield of Lakes Buchanan and Travis from 535,812 acre-feet to 536,312 acre-feet.
- 22) On June 2, 1997, the Commission issued its Order severing the water rights authorized by Certificate No. 14-5477B from Certificate No. 14-5477(Pierce Ranch), as amended, and combined it with LCRA's water rights authorized by Certificate No. 14-5475. (LCRA's Lakeside Irrigation Service Area)
- 23) LCRA proposed amendments to the WMP reflect the Commission's June 2, 1997 Order.

- 24) LCRA is proposing throughout the current WMP several non-substantive amendments to reflect factual changes that have occurred during the period 1993-1997 relating to water demands, both actual and projected; changes to models; operations procedures; LCRA Board Policy and general background information. All of these proposed non-substantive amendments to the current WMP are detailed in mark-ups of the current WMP dated May 28, 1997, December 29, 1997 and September 29, 1998 that have been filed with the Commission by the LCRA.

#### CONCLUSIONS OF LAW

- 1) The Commission considered this Order under the authority and in accordance with Chapter 11 of the Texas Water Code, as amended, and 30 Texas Administrative Code ("TAC") § 295 et. al.
- 2) The Commission has jurisdiction to consider and take action on LCRA's application to amend its Water Management Plan.

NOW, THEREFORE, BE IT ORDERED BY THE TEXAS NATURAL CONSERVATION COMMISSION THAT:

- 1) LCRA's proposed amended Water Management Plan, which includes LCRA's amended Drought Management Plan as reflected in LCRA's detailed mark-ups of the current WMP dated May 28, 1997, December 29, 1997 and September 29, 1998, is approved with the following conditions:
  - a) LCRA's amended Water Management Plan is subject to all findings, conclusions, and conditions contained in the Commission's September 20, 1989 Order approving the Plan, except to the extent specifically provided otherwise by this Order.
  - b) LCRA's amended Drought Management Plan is subject to all findings, conclusions, and conditions, contained in the Commission's December 23, 1991 Order approving the Plan, except to the extent specifically provided otherwise by this Order.
  - c) LCRA's amended Water Management Plan, including LCRA's amended Drought Management Plan, is subject to all findings, conclusions, and conditions contained

in the Commission's December 18, 1992 Agreed Order approving amendments to the Plans, except to the extent specifically provided otherwise by this Order.

- d) Any party shall have the right, at any time, to petition the Commission to seek to amend or clarify any issue in connection with LCRA's amended Water Management Plan, which includes LCRA's amended Drought Management Plan. Nothing in this Order shall be construed to impair any party's right to contest or seek clarification of, at anytime, any issue in connection with LCRA's amended Water Management Plan, which includes LCRA's amended Drought Management Plan.
  - e) The Commission takes notice that in 1993 the Sierra Club contested the issue of priority of use of interruptible water and that contest has been remanded to the State Office of Administrative Hearings ("SOAH") for hearing and is still pending.
  - f) Nothing in this Order shall be construed as deciding the issue pending at SOAH. Furthermore, if as a result of that hearing, the priority of use for interruptible water, as it relates to instream flows, is determined by the Commission to be different than that set forth in these Plans, any party shall have the express right to reopen the issue of instream flow and bay and estuary inflow requirements by submitting a written request for hearing to the Commission.
- 2) The Chief Clerk of the Texas Natural Resource Conservation Commission shall forward a copy of this Order subject to the filing of motions for rehearing, to all parties.
  - 3) If any part of this Order is for any reason held to be invalid, the invalidity of any portion shall not affect the validity of the remainder of the Order.
  - 4) If the Texas Parks and Wildlife Department, the Texas Water Development Board, or the Commission, acting on their own motion or as a result of a petition filed by any party, shall


determine that there is a need for any updates to the freshwater inflow needs as a result of a new study for the Matagorda Bay System, the LCRA shall amend its amended Water and Drought Management Plans and submit these proposed amendments to the Commission for review and approval within one (1) year of completion of such new studies. Any party may reopen the issue of bay and estuary inflows by submitting a written request for hearing to the Commission within thirty (30) days of receiving notice of the filing of the new studies or any proposed amendment to the Plans.

- 5) Nothing in LCRA's Amended Water Management Plan and Amended Drought Management Plan or this Order shall be construed to impair, or to authorize LCRA or any other person or entity to impair, senior or superior water rights in the Colorado River Basin.

ISSUED: MAR 01 1999

TEXAS NATURAL RESOURCE

CONSERVATION COMMISSION

  
Robert J. Huston, Chairman

Appendix C-5

Order overruling objections to LCRA's system of priorities set forth in  
its Water Management Plan,  
Dated June 3, 2003

# TEXAS COMMISSION ON ENVIRONMENTAL QUALITY



**AN ORDER** overruling the objections of the Texas Chapter of the Sierra Club, Texas Parks and Wildlife Department, and the City of Austin to the Lower Colorado River Authority's system of priorities for its interruptible water supply set forth in its Water Management Plan; TCEQ Docket No. 1995-1317-WR.

On May 29, 2003, the Texas Commission on Environmental Quality (Commission) considered the objections of the Texas Chapter of the Sierra Club (Sierra Club), Texas Parks and Wildlife Department (TPWD), and the City of Austin (Austin) to the Lower Colorado River Authority's (LCRA) system of priorities for its interruptible water supply set forth in its Water Management Plan. The objections were presented to the Commission with a Proposal for Decision by Carol Wood, an Administrative Law Judge (Judge) with the State Office of Administrative Hearings.

After considering the Judge's Proposal for Decision and the evidence and arguments presented, the Commission makes the following Findings of Fact and Conclusions of Law:

## FINDINGS OF FACT

1. On July 29, 1985, the Texas Water Commission, predecessor agency of the Texas Commission on Environmental Quality (Commission), issued its Final Determination in the Adjudication of the Lower Colorado River Segment (Final Determination).
2. Five water rights holders, including the Lower Colorado River Authority (LCRA) and the City of Austin (Austin), filed exceptions to the Final Determination in district court in Bell

County, Texas.

3. Prior to the entry of the Final Judgment and Decree (Final Judgment) in district court, the Commission on February 4, 1988, adopted a resolution agreeing to the settlement of LCRA's and Austin's water right claims in the lower Colorado River ("Resolution Agreeing to Settlement of Cause No. 115,414-A-1"). The resolution stated that, with respect to the operation of the Highland Lakes, several entities, including the Texas Parks and Wildlife Department (TPWD) and the Texas Chapter of the Sierra Club (Sierra Club), had expressed concerns regarding protection of instream flows, water quality, and bays and estuaries.
4. On June 28, 1989, the Commission issued Certificates of Adjudication Nos. 14-5478 (Lake Buchanan) and 14-5482 (Lake Travis) to LCRA. In both Certificates, Paragraph 2.B entitled "Use" reads as follows:

LCRA is authorized to divert and use not to exceed 1,500,000 acre-feet of water per annum from [the Lakes] for municipal, industrial, irrigation and mining purposes, subject to the following conditions:

\* \* \*

- (5) Each commitment by LCRA to supply water under this Certificate . . . shall be considered to be on a firm, uninterruptible basis unless the contract, resolution or special condition defining such commitment specifically provides that such commitment 'is subject to interruption or curtailment'.

5. The Commission incorporated a condition into LCRA's Certificates of Adjudication Nos. 14-5478 and 14-5482 that required LCRA to prepare and submit to the Commission a proposed reservoir operation plan that would cover several "relevant public policies." Those policies included the following:
  - a. Recognition of the necessity of beneficial inflows from the Colorado River into the Lavaca-Tres Palacios Estuary consistent with § 11.147 of the Texas Water Code;



- b. Protection of fish and wildlife habitats consistent with § 11.147 of the Texas Water Code;
  - c. Consideration of the effects, if any, on existing instream uses and water quality consistent with § 11.147 of the Texas Water Code;
  - d. Mitigation of adverse impacts, if any, on wildlife habitats inundated by new reservoir construction;
  - e. Mitigation of adverse environmental impacts, if any, caused by new projects taking, storing or diverting in excess of 5,000 acre-feet per year consistent with § 11.152 of the Texas Water Code; and
  - f. Recognition of the Commission's statutory authority to require water conservation under § 11.134(b)(4) of the Texas Water Code.
6. The Certificates of Adjudication issued to LCRA on June 28, 1989, further provide the following:
- LCRA shall interrupt or curtail the supply of water under [the Certificates] pursuant to commitments that are specifically subject to interruption or curtailment, to the extent necessary to allow LCRA to satisfy all demands for water under such certificates pursuant to all firm, uninterruptible commitments. Commitments to supply water on a non-firm, interruptible basis may be interrupted or curtailed as necessary either on a pro rata basis or in accordance with a system of priorities, as may be set forth in various contracts and resolutions that define such commitments.
7. Nowhere in either Certificate of Adjudication issued to LCRA is there any reservation from appropriation of any water for instream flows or freshwater inflows to bays and estuaries.
8. On July 10, 1989, LCRA submitted to the Commission a proposed Water Management Plan (Plan). According to the Plan, demands for "interruptible water" are met to the extent water is available each year after firm demands are satisfied.
9. The vast majority of LCRA's commitments for interruptible water are for irrigation downstream, and most of the irrigation is for rice farming.

10. Four downstream irrigation operations (Gulf Coast and Lakeside, which are owned and operated by LCRA, and Garwood and Pierce Ranch Irrigation Companies) have commitments with LCRA that gives them "first priority" for interruptible stored water.
11. On September 20, 1989, the Commission issued an Order conditionally approving LCRA's Plan and amending LCRA's Certificates of Adjudication Nos. 14-5478 and 14-5482. The Order required LCRA to do the following:
  - a. Conduct an instream study with TPWD and submit an application to amend the Plan to reflect the results of the instream study.
  - b. Complete a freshwater inflows study with TPWD and the Texas Water Development Board (TWDB) and submit an application to amend the Plan to reflect the results of that study.
  - c. Within one year, submit a drought contingency plan for Commission review and approval.
12. Provision No. 1(a) entitled "Use" in Amendment to Certificate of Adjudication No. 14-5482A granted September 7, 1989, reads as follows:

In addition to the authorizations included in Paragraph 2.B, USE of Certificate No. 14-5482 to divert and use water from Lake Travis for municipal, industrial, irrigation and mining purposes, certificate owner is authorized to divert, use and release waters from Lake Travis for domestic, recreation, instream flows and bay/estuary purposes.
13. Provision No. 1(a) entitled "Use" in Amendment to Certificate of Adjudication No. 14-5478A, granted September 7, 1989, reads as follows:

In addition to the authorizations included in Paragraph 2.B., USE of Certificate No. 14-5478 to divert and use water from Lake Buchanan for municipal, industrial, irrigation and mining purposes, certificate owner is authorized to divert, use and release waters from Lake Buchanan for domestic, recreation, instream flows and bay/estuary purposes.
14. On October 19, 1990, LCRA filed its proposed drought contingency plan.

15. On December 23, 1991, the Commission issued an Order conditionally approving LCRA's drought contingency plan. Although entitled "Drought Management Plan," LCRA's drought contingency plan is Section 2 of LCRA's Water Management Plan.
16. Sierra Club challenged the provisions of the conditionally approved Plan that gave to the four downstream irrigation operations "first priority" for interruptible stored water.
17. LCRA and TPWD completed their instream flow needs study for the lower Colorado River and, on December 18, 1992, the Commission issued an Order conditionally approving LCRA's amendments to the Plan to adopt the instream flow requirements.
18. The issue of priority of use of interruptible water in LCRA's Plan, opposed by Sierra Club, was remanded for hearing in October, 1992.
19. A preliminary hearing on the matter was conducted on February 9, 1993. The following were designated as parties to the proceeding: LCRA, the Commission's Executive Director, the Commission's Public Interest Counsel, Sierra Club, TPWD, Austin, and Garwood Irrigation Company.
20. Additional prehearings were held in 1993, 1999, 2000, and 2002.
21. In 1993, LCRA, TWDB, TPWD, and the Commission entered into a cooperative agreement to complete a bay/estuary study.
22. The bay/estuary study was completed in 1997, and LCRA filed its proposed amendments to the Plan to reflect the results of the study.
23. On March 1, 1999, the Commission issued an Order conditionally approving LCRA's amendments to the Plan to adopt the freshwater inflow requirements.

24. Pursuant to the Plan, the four downstream irrigation operations have commitments with LCRA that give them "first priority" for LCRA's interruptible stored water supply.
- a. During the irrigation season, irrigation needs are met, as are instream flow needs and the needs of freshwater inflows to bays and estuaries, with the stored interruptible waters released by LCRA that flow downstream.
  - b. During the non-irrigation season, LCRA allocates a portion of the Highland Lakes' (Lakes) firm yield water for instream flow purposes regardless of priorities and inflows to the Lakes. A portion of the Lakes' firm yield is allocated by LCRA for freshwater inflows to bays and estuaries, regardless of priorities, to the extent of inflows to the Lakes (up to 15,900 acre-feet annually).
25. According to the Plan, the amount of instream flow to be maintained in the lower Colorado River is based on the level of the combined storage of the Highland Lakes.
- (1) Target flows will be maintained until the four downstream irrigation operations are curtailed (at 1.1 million acre-feet), to the extent inflows are available each day for storage as measured by upstream stream gages.
  - (2) When the four irrigation operations are curtailed, critical flows (a flow of at least 46 cubic feet per second at the Austin stream gage) will be maintained at all times, even if LCRA has to release stored water.
  - (3) The four irrigation operations are curtailed in proportion to the Lakes' storage content.
26. The Plan sets freshwater inflow needs for bays and estuaries at critical and target flows.
- (1) Target flows will be met when the Highland Lakes' combined storage level is greater than 1.7 million acre-feet (AF), to the extent of inflows each month to the Lakes.
  - (2) Critical flows will be met below 1.7 million AF, to the extent of inflows each month to the Lakes.

## CONCLUSIONS OF LAW

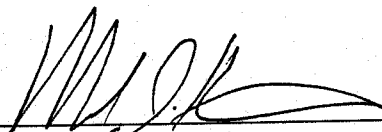
1. The Commission considered this Order under the authority of and in accordance with Chapter 11 of the TEX. WATER CODE (Water Code), as amended (West 2002), and 30 TEX. ADMINISTRATIVE CODE (TAC) § 295 *et seq.* (2002).
2. The Commission has jurisdiction to consider and take action on the objections to LCRA's system of priorities for its interruptible water supply set forth in its Water Management Plan.
3. In accordance with Water Code § 11.301 *et seq.*, LCRA's interruptible water supply is part of the state water the Commission authorized LCRA to appropriate in Certificates of Adjudication Nos. 14-5478 and 14-5482 issued June 28, 1989.
4. The considerations set out in Water Code § 11.147 do not preclude LCRA's interruptible water supply scheme.
5. Neither LCRA's Certificates of Adjudication, the Water Code, nor the Commission's rules prohibit LCRA from curtailing environmental flows before curtailing the four irrigation operations set out in the Plan.
6. Neither state law nor the common law principles of the public trust doctrine require LCRA to afford instream uses "first priority," or preference over other uses, of its interruptible water supply.
7. Neither state law nor the public trust doctrine requires LCRA to revise its Water Management Plan to give instream uses first priority for its interruptible water supply.
8. The priority of use for LCRA's interruptible water supply as it relates to instream uses should be as specified in LCRA's Water Management Plan.

**NOW, THEREFORE IT IS ORDERED BY THE TEXAS COMMISSION ON ENVIRONMENTAL QUALITY THAT:**

1. The objections of the Texas Chapter of the Sierra Club, Texas Parks and Wildlife Department, and the City of Austin to the Lower Colorado River Authority's system of priorities for its interruptible water supply set forth in LCRA's Water Management Plan are overruled.
2. The Chief Clerk of the Texas Commission on Environmental Quality shall forward a copy of this Order, subject to the filing of motions for rehearing, to all parties.
3. If any part of this Order is for any reason held to be invalid, the invalidity of that portion shall not affect the validity of the remainder of this Order.

Issue Date: JUN 03 2003

TEXAS COMMISSION ON  
ENVIRONMENTAL QUALITY

  
Robert Huston, Chairman

Appendix C-6  
Agreed Order Approving Amendments to LCRA's  
Water Management Plan,  
Dated January 27, 2010

# TEXAS COMMISSION ON ENVIRONMENTAL QUALITY



## AGREED ORDER APPROVING AMENDMENTS TO LOWER COLORADO RIVER AUTHORITY'S WATER MANAGEMENT PLAN

On the 27<sup>th</sup> day of January, 2010, the Texas Commission on Environmental Quality ("Commission") considered the Lower Colorado River Authority's ("LCRA") application (Application No. 5838) to amend its Water Management Plan (WMP) and having heard evidence and arguments concerning Application No. 5838 and the proposed order, the Commission makes the following Findings of Fact and Conclusions of Law:

### FINDINGS OF FACT

- 1) LCRA's Application No. 5838 to amend the WMP was received by the Commission on May 16, 2003, and was declared administratively complete on May 7, 2004.
- 2) Notice of the application to amend the WMP and of the public meeting on the proposed amendments to the WMP was published on September 27, 2004, in the Austin American-Statesman, a newspaper regularly published and generally circulated in Travis County, Texas; on September 29, 2004, in the Colorado County Citizen, a newspaper regularly published and generally circulated in Colorado County, Texas; on October 10, 2004, in the Matagorda County Tribune, a newspaper regularly published and generally circulated in Bastrop County, Texas; on October 10, 2004, in the Bay City Tribune, a newspaper regularly published and generally circulated in Matagorda County, Texas; on October 1, 2004, in the Fayette County Record, a newspaper regularly published and generally circulated in Fayette County, Texas; on September 29, 2004, in the El Campo Leader-News, a newspaper regularly published and generally circulated in Wharton County, Texas; and on September 25, 2004, in the Bastrop Advertiser, a newspaper regularly published and generally circulated in Bastrop County, Texas. These counties are the only counties in which persons reside who may be affected by action taken by the Commission on the proposed amendments.
- 3) On September 14, 2004, notice of an application to amend the WMP and notice of the public meeting was sent by first-class mail to the water right holders of record in the Colorado River Basin as required by law.
- 4) On November 8, 2004, the Commission held a public meeting. One person presented oral comments, and five (5) entities provided written comments in opposition to the proposed amendments.
- 5) The following persons/entities filed protests and requested a contested case hearing with the Commission regarding the proposed amendments: STP Nuclear Operating Company; City of Austin; Texas Parks and Wildlife Department; Sierra Club, Lone Star Chapter; and the National Wildlife Federation.



- 6) The applicant, LCRA, has requested numerous editorial and organization changes to the WMP designed to correct errors, improved readability and achieve internal consistency in the documents. All of these proposed non-substantive amendments to the WMP are detailed in mark-ups of the existing approved WMP dated May 16, 2003, June 10, 2004, April 29, 2005, March 1, 2006, April 24, 2009, November 25, 2009, and December 17, 2009, that were filed with Commission by the LCRA.
- 7) LCRA's proposed amendments to the WMP fall within four areas: curtailment policy for interruptible stored water supplies; allocation of stored water for environmental protection; incorporation of LCRA's Drought Contingency Plan into the WMP; and update of the WMP Appendices.
- 8) LCRA's proposed amendments to the WMP show the 2000 reported surface water demands by its firm customers from all sources of supply as approximately 296,600 acre-feet annually. The ten-year projected firm demands (through 2010), developed in 2000, were approximately 360,071 acre-feet per year - an increase of 63,471 acre-feet per year. The primary reason for this projected increase is additional water use around the Highland Lakes. Since LCRA filed its application in 2003, its obligations to provide firm supply to the STP Nuclear Operating Company (STPNOC) have been clarified in an Amended and Restated Contract which, among other things, obligates LCRA to provide no more than 20,000 acre-feet per year (rolling five-year average) of firm supply for up to two nuclear generating units and up to 40,000 acre-feet per year (rolling five-year average) of firm supply for more than two generating units, with staged deliveries based on STPNOC's reservoir level subject only to LCRA bay and estuary restrictions and according to a Water Delivery Plan. Contractual Permit No. 327A was issued by the Commission on August 31, 2009, based on the Amended and Restated Contract and the included Water Delivery Plan. The total estimated firm demands for all LCRA customers to be satisfied under this WMP are sufficient to address any additional firm demand that STPNOC might have in the timeframe for which these present amendments to the WMP are intended to be effective, after taking into consideration firm water allocated for environmental purposes.
- 9) With this large projected increase in firm water demand, and because firm water demands take priority over all other uses, LCRA requested the proposed amendments to the WMP to provide a compensating reduction in interruptible supplies. This reduction will be achieved by revising the annual interruptible water supply curtailment policy. LCRA's proposal to amend curtailment policy is as follows:
  - (a) If the total water in storage in either Lakes Buchanan or Travis is less than 94% on January 1 or June 1, then interruptible water supplies will not be made available to any customers located outside the four downstream irrigation operations (Pierce Ranch, Garwood, Gulf Coast, and Lakeside).
  - (b) If the total combined water in storage in Lakes Buchanan and Travis on January 1 is equal to or greater than 1,400,000 acre-feet, then LCRA will supply the interruptible stored water demands of the downstream four irrigation operations. This is based on the assumption that the maximum annual demand for the interruptible stored water acreage of 83,700 acres projected for 2010, under a 1 in 5 dry year condition, was 273,000 acre-feet. Using that as the greatest interruptible stored water demand, a set of smaller interruptible stored water supplies were assumed to generate a set of first and second crop acreages expected to be cultivated by each particular irrigation operations.

- (c) Curtailment of interruptible supply to the irrigation operations will commence when the total combined January 1 storage in Lake Buchanan and Travis is less than 1,400,000 acre-feet. When the combined storage in Lakes Buchanan and Travis on January 1 is between 1,400,000 acre-feet and 1,150,000 acre-feet, the interruptible stored water supply available will vary beginning at 273,000 acre-feet available at 1.4 million acre-feet of storage and decreasing at a rate of approximately 31,200 acre-feet for each 100,000 acre-foot decrease in combined storage until a value of 195,000 acre-feet available at a combined storage of 1.15 million acre-feet. When the combined storage in Lakes Buchanan and Travis on January 1 is less than 1,150,000 acre-feet, the interruptible stored water supply made available to the irrigation operations will vary beginning at 195,000 acre-feet available at 1.15 million acre-feet of storage and decreasing at a rate of approximately 4,250 acre-feet for each 100,000 acre-foot decrease in combined storage until a value of 160,000 acre-feet available at a combined storage of 325,000 acre-feet. This curtailment is depicted in Figure 4-1 of the Water Management Plan.
  - (d) Cutoff of the interruptible stored water supply for any purpose for the coming year will occur when the combined storage in Lakes Buchanan and Travis on January 1 is less than or equal to 325,000 acre-feet.
  - (e) If at any time during the year the total storage in Lakes Buchanan and Travis, combined, is less than or equal to 200,000 acre-feet, then all use of interruptible stored water will be stopped.
  - (f) During any period of curtailment or cutoff of interruptible supplies to the irrigation operations that is instituted on January 1, LCRA will cancel such curtailment at any time during the year prior to July 31, if the combined storage in Lakes Buchanan and Travis is projected to be equal to or greater than 1,400,000 acre-feet anytime in July. Further, the remaining available interruptible stored water supplies for the year may be reallocated, at this time, between irrigation operations if such allocations do not adversely affect any irrigation operation.
  - (g) During periods of curtailment, LCRA will allow each irrigation operation the option of either: (1) using up to a maximum authorized volume of interruptible stored water allocated to that operation, or (2) using sufficient water to cultivate a level of acreage agreed upon among the customers within each irrigation operation and LCRA.
- 10) LCRA's proposed amendments to the WMP also include a change in the procedure for supplying water for instream flow needs at certain locations downstream of Lady Bird Lake.
- (a) To the extent that inflows are legally available for storage in Lakes Buchanan and Travis, LCRA will release such inflows to help satisfy target instream flow needs, as set out in Table 2-1 of the WMP, whenever the combined water storage in Lakes Buchanan and Travis on January 1 is at or above 1,400,000 acre-feet.

- (b) LCRA will make such releases from Lakes Buchanan and Travis as are needed to help maintain critical instream flows, as set out in Table 2-1 of the WMP, at certain locations downstream of Lady Bird Lake. The level of releases to help maintain critical instream flows will not be limited by the inflows that are legally available for storage in Lakes Buchanan and Travis.
  - (c) In rare instances, LCRA's ability to meet the instream flow requirements set forth in this WMP may be impaired by certain unavoidable constraints such as the capacity of its hydro-generation units and hydro-generation scheduling mandates as well as unforeseen diversions, unforeseen changes in flow conditions downstream, and adjustments to the ratings of the applicable gages.
- 11) LCRA's proposed amendments to the WMP include a change in the reservoir operation procedure for providing water for estuarine fresh water inflow needs. The proposed amendment adds an intermediate level of supply for estuarine freshwater inflows that provides for a slightly more gradual reduction of the supply made available to Matagorda Bay than contained in the previously approved WMP. LCRA is required to release water from Lakes Buchanan and Travis to help maintain monthly estuarine inflows in accordance with the following procedure only to the extent that inflows are legally available for storage in Lake Buchanan and Travis as measured at the upstream gages:
  - (a) when the combined storage in Lakes Buchanan and Travis on January 1 is greater than or equal to 1,700,000 acre-feet, LCRA will release those storable inflows up to but not exceeding the amount needed to provide target freshwater inflow needs; and
  - (b) when the combined storage in Lakes Buchanan and Travis on January 1 is less than 1,700,000 acre-feet and greater than 1,100,000 acre-feet, LCRA will release those storable inflows up to but not exceeding the amount needed to provide one hundred and fifty percent of the critical freshwater inflow needs; and
  - (c) when the combined storage in Lakes Buchanan and Travis on January 1 is equal to or less than 1,100,000 acre-feet, LCRA will release those storable inflows up to but not exceeding the amount needed to provide critical freshwater inflows in all years.
- 12) The proposed amendments are deemed by LCRA as a balance between a modest incremental decrease in irrigation water supplies during drought conditions and modest increased inflow to Matagorda Bay during non-drought years to help maintain ecologically important freshwater inflows to the Bay.
- 13) Based on LCRA's determination of a balance of environmental and irrigation impacts, the recommended amendments to the WMP include an increase of stored water released for estuarine freshwater inflow. This increase would be provided in years when the January 1 storage level in Lakes Buchanan and Travis is between 1,100,000 and 1,700,000 acre-feet (55 and 86 percent full, respectively).
- 14) Among the issues raised in the hearing requests filed regarding the proposed amendments was the degree to which the amendments reflected consideration of the best information on environmental flow needs available at that time. While that issue remains in dispute, all parties agree that credible and extensive scientific information relating to environmental flow needs is available at

this time that is not incorporated in this order, but should be considered in developing and implementing an updated version of the WMP in the near future. That credible scientific information includes but is not limited to the August 2006 Matagorda Bay Freshwater Inflow Needs Study; the October 10, 2008 Matagorda Bay Health Evaluation; the March 31, 2008 Lower Colorado River, Texas Instream Flow Guidelines; and data collected by LCRA, TPWD, TWDB, and other agencies and researchers.

- 15) During the critical drought, LCRA proposes that the total stored water provided for environmental protection remain essentially the same as provided under the previously approved WMP. However, LCRA's proposed amendments provide that more of this commitment be met with firm, rather than interruptible stored water. The firm stored water so designated would increase from 16,950 acre-feet to 33,440 acre-feet. This additional firm commitment would be provided from available, but uncommitted supplies from Lakes Buchanan and Travis.
- 16) The LCRA Drought Contingency Plan (DCP), as required by Commission rules (30 Texas Administrative Code §§ 288.20 *et seq.*), was approved by the LCRA Board of Directors and submitted to the Commission in April 2000. The 2000 DCP was based on Chapter 4 of the WMP. Under current Commission rules, the DCP must be updated every five years. The DCP filed by LCRA with the Commission in 2000 was updated and approved by the LCRA Board of Directors and submitted to the Commission in April 2005. Consistent with the requirements of Chapter 288 of the Commission rules, LCRA also reviewed its DCP prior to May 1, 2009, but did not make any further changes to the DCP at that time. In December 2009, the LCRA Board approved further modifications to the DCP to reflect customer comment received in response to recent severe drought conditions. LCRA has submitted redline changes to Chapter 4 of the WMP that incorporates these recent changes.
- 17) On March 29, 1996 the Commission issued an Order severing a portion of the water rights authorized by Certificate of Adjudication No 14-2564 and combining them with LCRA's Certificate of Adjudication No. 14-5478 (Lake Buchanan). Certificate of Adjudication 14-5478C was issued to LCRA on the same date and authorized LCRA to transfer 532 acre-feet of water downstream to Lake Buchanan and consumptively use 500 acre feet per year of this water. Because the priority date of the severed water was senior to LCRA's rights to divert water from Lake Buchanan, LCRA requested and was granted on March 4, 1999, an increase in the Combined Firm Yield of Lakes Buchanan and Travis from 535,812 acre-feet to 536,312 acre-feet.
- 18) On August 29, 2003, LCRA filed a request with the Commission to cancel Certificate of Adjudication 14-5478C and for the Commission to rescind the March 29, 1996 Order severing water rights from Certificate Adjudication 14-2564 and combining them with LCRA's water rights authorized by Certificate of Adjudication 14-5478. On March 22, 2004, LCRA filed a Request to Abandon Certificate of Adjudication 14-5478C. Based on the abandonment, LCRA proposes that the WMP be amended to reflect a Combined Firm Yield of 535,812 acre-feet of water, which is the amount of the Combined Firm Yield prior to the issuance of Certificate of Adjudication 14-5478C.
- 19) The WMP contains two appendices: Volume I, which includes relevant LCRA Board policies, and Volume II, which contains technical information on the WMP and previous amendments. Changes to Volume I will reflect revisions made to LCRA Board policies since 1999. Changes to Volume II will reflect changes in agreements between LCRA and the Colorado River Municipal Water District, delete obsolete appendices, and update LCRA's standard form contracts and raw water contract rules.

- 20) LCRA supports this Order. In order to provide some certainty and to ensure prompt action on a new revision to the WMP, each of the parties identified in Finding of Fact No. 5 agree not to oppose the approval of this Order.

#### CONCLUSIONS OF LAW

- 1) The Commission considered this Order under the authority and in accordance with Chapter 11 of the Texas Water Code, as amended, and 30 Texas Administrative Code ("TAC") Chapter 295.
- 2) The Commission has jurisdiction to consider and take action on LCRA's application to amend the WMP.

NOW, THEREFORE, BE IT ORDERED BY THE TEXAS COMMISSION ON ENVIRONMENTAL QUALITY THAT:

- 1) LCRA's amended Water Management Plan is approved with the following conditions:
- a) LCRA's amended Water Management Plan is subject to all findings, conclusions, and conditions contained in the Commission's Order dated September 20, 1989, December 23, 1991, December 18, 1992 and March 1, 1999, approving and amending the WMP, except to the extent that this Order specifically provides otherwise.
  - b) Notwithstanding any other provision in the revised Water Management Plan, for purposes of establishing LCRA's obligations to supply interruptible stored water for agricultural use within the four major irrigation operations and to provide water for instream flows and freshwater inflows in calendar year 2010, the following shall apply:
    - 1. LCRA's obligations to provide water for instream flows and freshwater inflows in January 2010 shall be governed by the Water Management Plan in effect on January 1, 2010.
    - 2. From February 1, 2010 through December 31, 2010, LCRA's obligations shall be governed by the WMP in effect on February 1, 2010. In providing interruptible stored water for agricultural use within the four major irrigation operations and in providing water for instream flows and freshwater inflows during this period, LCRA's obligations shall be determined based on the combined storage in Lakes Buchanan and Travis on February 1, 2010.
  - c) LCRA shall implement the provisions of the amended Water Management Plan regarding the provision of instream flows in a manner so as maintain, on an instantaneous basis, instream flows of 46 cfs and 500 cfs critical flows as set forth in Table 2-1 during the times those respective flow values are in effect. During those times when the target instream flow requirements as set forth in Table 2-1 of the WMP are in effect, LCRA will schedule the passage of inflows to lakes Buchanan and Travis that are legally available for storage to maintain the target flows as a daily average. Furthermore, during those times when target instream flow requirements are in effect and when such inflows are sufficient to allow LCRA to satisfy the daily target flow requirement at the Bastrop gage, LCRA will also schedule the passage of

these inflows to maintain the following minimum flows, as measured at any time at the Bastrop gage:

<b>Month</b>	<b>Minimum Flow (cfs) 100% of the time</b>	<b>Minimum Flow (cfs) 95% of the time</b>
January	266	
February	269	
March	233	
April	244	287
May	492	579
June	355	418
July	295	347
August	165	
September	201	
October	208	
November	241	
December	264	

It is hereby recognized that, in rare instances, LCRA's ability to meet the instream flow requirements set forth in this WMP may be impaired by certain unavoidable constraints such as the capacity of its hydro-generation units and hydro-generation scheduling mandates as well as unforeseen diversions, unforeseen changes in flow conditions downstream, and adjustments to the ratings of the applicable gages.

- d) For purposes of estimating required releases of water from Lakes Buchanan and Travis to meet the instream flow or freshwater inflow requirements of this WMP, LCRA shall rely on stage data obtained from the gaging system jointly maintained and operated by the U.S. Geological Survey and LCRA for determining these requirements. If the ratings used to convert stage to flow published by LCRA and the USGS are not identical at the time required releases are estimated, LCRA shall have discretion to rely on the latest updated rating of the gage.
- e) The approval of the amended WMP does not reflect a final determination, or create a presumption, that the environmental flow provisions contained therein are adequate or appropriate based upon more recent information available at this time.
- f) Because of the importance of updating the environmental flow and drought curtailment provisions of the WMP to reflect the best available science and information, LCRA shall promptly initiate, by not later than July 1, 2010, a revision process designed to develop further proposed amendments to the Water Management Plan. The revision process should be reasonably calculated to allow meaningful participation by interested basin stakeholder groups and to achieve regional consensus, where possible.

LCRA shall file an application for approval of proposed amendments with the Executive Director by not later than July 1, 2013. That application shall include a summary of the steps taken by LCRA to further public participation and to achieve consensus, where possible, in developing the proposed amendments. To the extent that the Executive Director determines such application is not administratively complete, LCRA shall make reasonable and good faith efforts to timely provide any

additional information necessary to have the application declared administratively complete at the earliest possible time.

Those proposed amendments shall address, at a minimum, the following:

1. Interruptible curtailment procedures needed to ensure that LCRA can satisfy projected firm customer demand should intense drought conditions such as those experienced over the past several decades recur;
2. An evaluation of the adequacy of the criteria for declaring a drought worse than drought of record;
3. An evaluation of the minimum combined storage of water in Lakes Buchanan and Travis necessary or appropriate to protect firm customers through a repeat of the drought of record or under conditions worse than a drought of record;
4. Incorporation of appropriate changes to reflect LCRA's agreements and obligations to STPNOC under the Settlement Agreement and Amended and Restated Contract, including the Water Delivery Plan;
5. LCRA's agreement with the City of Austin regarding return flows, consistent with Section VIII(C)(1) of the Settlement Agreement by and between the City of Austin and the LCRA Regarding Joint Water Resource Management and the Resolution of Certain Regulatory Matters Pending at the TCEQ, dated June 18, 2007;
6. Revisions to provisions governing the manner in which LCRA provides water from Lakes Buchanan and Travis to address environmental flow needs that shall use the best available scientific information, including the information referenced in Finding of Fact 15, and shall provide water for such needs to the maximum extent reasonable and practicable when considering all public interests as set forth in Texas Water Code §11.147 and any applicable environmental flow standards adopted pursuant to Texas Water Code § 11.1471. Such revisions shall include:
  - i. a mechanism for adjusting the manner in which LCRA provides water for environmental flow needs that addresses significant improvements in storage conditions during the course of a year;
  - ii. a mechanism for limiting harmful intra-daily fluctuations of instream flows to prevent significant adverse impacts from periods of low flows; and

- iii. specification, to the maximum extent reasonable, of an overall instream flow regime.

The Commission hereby directs the Executive Director's staff to make all reasonable efforts to complete its technical review of the application for proposed amendments to the Water Management Plan by not later than one year after the date of LCRA's application is declared administrative complete and, as part of that staff review process, to allow other interested persons who request the opportunity to do so to submit, consistent with the timeline established by Commission staff, information regarding environmental flow issues and other issues addressed by the amendments for consideration. To facilitate the prompt completion of the technical review, LCRA shall respond fully to all requests from the Executive Director's staff for additional information within 30 days after receipt of those requests unless otherwise agreed upon by the Executive Director's staff. Upon completion of the technical review, the application and associated hearing requests, if any, on that application will be given high priority and set for prompt consideration and action by the Commission.

- g) Consistent with 30 Tex. Admin. Code Ch. 288, LCRA shall review and update, as appropriate, in accordance with the schedule required by such rules, those portions of Chapter 4 that relate to its Drought Contingency Plan (DCP) that do not change the triggers or amount of curtailment of interruptible supply or the triggers related to instream flows and bay and estuary inflows. Changes to other portions of the DCP, including any changes to LCRA's specific, quantified targets for water use reductions of firm customers required by chapter 288, do not constitute an amendment to the Water Management Plan requiring notice and an opportunity for contested case hearing, but must otherwise comply with the public notice requirements of Chapter 288 of the Commission's rules. Prior to implementing any mandatory firm water customer curtailment allowed under Texas Water Code section 11.039, LCRA shall work with its firm customers to develop a specific water curtailment plan, which must be approved by the LCRA Board and the Commission pursuant to other applicable procedures.
- h) Nothing in this Order shall be construed to impair or limit any party's right to contest the LCRA's proposal for incorporating the results of existing or future freshwater inflow or instream flow studies in any future proceedings relating to amendments of the Water Management Plan.
- i) Nothing in this Order, other than Findings of Fact 17 and 18, shall be construed as addressing the calculation of the combined firm yield of Lakes Buchanan and Travis and no party shall be deemed to have waived the right to contest in any future proceeding the calculation of the combined firm yield of Lakes Buchanan and Travis solely as a result of this Order.
- j) The Commission acknowledges the challenges to the adequacy of the environmental flow provisions included in the proposed amendments to the Water Management Plan previously raised by the Texas Parks and Wildlife Department, National Wildlife Federation, and the Lone Star Chapter of the Sierra Club. Those parties have agreed that compliance by LCRA with the provisions of this Order would eliminate the need for a Commission proceeding



to resolve those challenges. However, in the event that LCRA fails to meet any requirement set out in decretal paragraph (f) above, the Commission expressly recognizes that the issues raised by those challenges will again require consideration. Accordingly, any of those parties may, if it has reason to believe LCRA has failed to meet any such requirement, file, with the Office of the Chief Clerk, a written request seeking a hearing on the adequacy of environmental flow provisions approved by this Order and detailing the alleged failure by LCRA to comply with the requirements of decretal paragraph (f). Any such hearing request shall be set for prompt consideration by the Commission and, subject to compliance with routine requirements for hearing requests, shall be granted unless the Commission determines that LCRA has fully complied with the requirements of decretal paragraph (f).

- k) LCRA agrees to be bound by the terms, conditions and provisions contained herein and such agreement is a condition precedent to the approval of the proposed amendments.
- l) LCRA shall conform the text of the Water Management Plan to be consistent with the provisions of this Order.
- 2) The Chief Clerk of the Texas Commission on Environmental Quality shall forward a copy of this Order, to all parties.
- 3) If any part of this Order held to be invalid, the invalidity of any portion shall not affect the validity of the remainder of the Order.
- 4) Nothing in LCRA's Water Management Plan, as amended, or this Order shall be construed to impair, or to authorize LCRA or any other person or entity to impair, senior or superior water rights in the Colorado River Basin.

  
For the Commission

DATE ISSUED **JAN 27 2010**

Appendix C-7  
Order approving LCRA's Firm Water Curtailment Plan  
Dated December 12, 2011

# TEXAS COMMISSION ON ENVIRONMENTAL QUALITY



## AN ORDER

approving the Lower Colorado River Authority's Water Curtailment Plan for its Firm Water Customers; Docket No. 2011-2097-WR

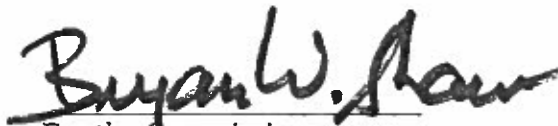
On December 7, 2011, the Texas Commission on Environmental Quality ("TCEQ" or "Commission") considered the request for approval of its Water Curtailment Plan, filed on October 21, 2011. LCRA's firm Water Curtailment Plan is an amendment to LCRA's Raw Water Drought Contingency Plan, which is included in LCRA's Water Management Plan, Permit No 5838. LCRA's Water Management Plan, required by its Certificates of Adjudication Nos. 14-5478 and 14-5482, provides how LCRA makes water available from Lakes Buchanan and Travis to meet "firm" water customer needs, downstream interruptible irrigation demands, and environmental flow needs of Matagorda Bay and the lower Colorado River. It also provides how LCRA will manage and curtail supplies from the lakes during times of drought including through a repeat of the Drought of Record. LCRA's Water Management Plan additionally requires that this Water Curtailment Plan be prepared before the LCRA implements mandatory firm water customer curtailment under Tex. Water Code § 11.039, and that this plan be approved by the LCRA Board and the Commission.

The Commission finds that the plan meets the requirements of Texas Water Code § 11.039 and 30 Tex. Admin. Code Chapter 288.

## THEREFORE, THE TEXAS COMMISSION ON ENVIRONMENTAL QUALITY ORDERS THAT:

Lower Colorado River Authority's Water Curtailment Plan filed October 21, 2011, is approved.

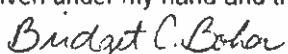
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

  
For the Commission

Issue Date: **DEC 12 2011**

THE STATE OF TEXAS  
COUNTY OF TRAVIS

I hereby certify that this is a true and correct copy of a Texas Commission on Environmental Quality document, which is filed in the permanent records of the Commission. Given under my hand and the seal of office on

 **DEC 14 2011**

Bridget C. Bohan, Chief Clerk  
Texas Commission on Environmental Quality

## **LCRA Firm Water Customer Curtailment Plan (for submittal to TCEQ)**

### **I. Purpose and Background.**

This plan is submitted for approval by the Texas Commission on Environmental Quality (TCEQ) consistent with LCRA's current TCEQ-approved Water Management Plan. This plan defines the general process under which LCRA will make water available during a pro rata curtailment in accordance with Texas Water Code § 11.039, and includes a variance procedure consistent with TCEQ rules. In developing the procedures within its raw water contract rules for implementing this plan, LCRA received and considered public input consistent with TCEQ rules. This plan will be treated as an amendment to LCRA's Raw Water Drought Contingency Plan (currently found in LCRA's Water Management Plan).

### **II. Determination of water to be made available during pro rata curtailment.**

In the event the LCRA Board orders a pro rata curtailment, the amount of water made available to all firm water customers will be reduced by an equal percentage from the customers' reasonable demands. The determination of a customer's available supply during a curtailment will be based on the following:

1. Actual water use from a dry 12-month period (the "Reference Year") will serve as the default "Baseline Amount" to which pro rata reductions would be applied. The Baseline Amount would not exceed customer's contracted annual quantity.
2. The Baseline Amount is subject to adjustment based upon conditions that caused customer's water use in the Reference Year to be reduced, including, but not limited to:
  - a. implementation of water conservation or drought contingency measures during the Reference Year which resulted in quantified and documented savings;
  - b. new growth and that will result in increases to customer's reasonable demands;
  - c. plant outages or other incidents that reduced demand; and
  - d. customer did not hold a contract for the entire Reference Year.
3. The amount of water to be made available to a customer during a curtailment (the "Annual Allotment") will be equal to the Baseline Amount, less the percentage curtailment ordered by the Board.
4. A variance to a customer's Annual Allotment will be considered if failure to grant a variance would result in a threat to public health, welfare or safety and there is no practical alternative water supply.

### **III. Customer Curtailment Plans**

Prior to a potential curtailment, firm water customers shall develop Customer Curtailment Plans. These plans shall include the customer's monthly or seasonal distribution of the customer's Annual Allotment. As part of the Customer Curtailment Plans, customers must identify or refer to specific measures to accomplish various levels of curtailment. In the event that a customer's Curtailment Plan represents a change to its Drought

Contingency Plan (DCP), the customer shall update its DCP and provide copies of the DCP to LCRA, and as required, to TCEQ.

#### IV. Implementation of Pro Rata Curtailment

In the event that the LCRA Board orders a pro rata curtailment, the order will include the pro rata percentage curtailment which will apply to each customer's Baseline Amount. If conditions change during a period of pro rata curtailment, the percentage curtailment may be increased or reduced by the LCRA Board.

During a pro rata curtailment, Customers will be required to use no more than their Annual Allotment as it may be pro-rated for portion of a calendar year in which curtailment is in effect. Customers who exceed their allotment will be subject to excess use rates or surcharges, to be specified by the LCRA Board, in addition to LCRA's firm water rate.

#### V. Cessation of Pro Rata Curtailment

In the event that the LCRA Board orders a pro rata curtailment, the order will include conditions under which the percentage curtailment may be adjusted or lifted.

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## **Appendix D**

### **LCRA Board Water Policies**

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**LCRA BOARD POLICY**  
**501 - WATER RESOURCES**  
**December 15, 2010**

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**501.10        PURPOSE**

This policy establishes principles and guidelines for implementing LCRA's responsibilities regarding water supply management, planning and development, water conservation, environmental flows, water quality protection, water contracts and rates, and the lowering of LCRA operated lakes.

**501.20        WATER SUPPLY MANAGEMENT, PLANNING AND DEVELOPMENT**

LCRA will take initiative in appropriate management, planning, programs, and projects to control, store, preserve, use, develop, conserve and manage the water supplies under its jurisdiction. To guide this effort, LCRA will adhere to the following general principles:

1. As a regional supplier, LCRA will, where practically feasible, cooperate with regional efforts, including regional water planning efforts, to benefit the Colorado River basin.
2. LCRA will optimize its water supply by managing the water stored in the lakes Buchanan and Travis with a basin-wide perspective of ensuring firm water supplies are available during an extended drought while continuing to make interruptible supplies available whenever possible. LCRA will achieve this objective, in part, through the development and implementation of its state-approved Water Management Plan.
3. LCRA will address unidentified future water supply needs and uncertainties through use of a reserve or some other mechanism to trigger acquisition of additional supplies.
4. While maximizing the potential supplies available from its Colorado River rights in a cost-effective manner, LCRA may consider development of new, cost-effective supplies to serve its customers.
5. LCRA will monitor developments in state water law and water rights permitting and, where necessary, take action to ensure that the legal rights and obligations LCRA has to manage the state's water resources are not significantly and adversely affected by such activities.
6. LCRA will stay fully apprised of developments regarding the legal framework under which groundwater is regulated and evaluate LCRA's role and the potential impacts to

LCRA. Through ongoing assessments of groundwater supplies, LCRA will encourage and research conjunctive management and use of ground and surface water supplies. LCRA may plan, develop, and manage conjunctive use projects where economically feasible, with the added goal of protecting and preserving the groundwater resources of the state.

7. LCRA will explore opportunities to improve the reliability of water supply for agricultural needs through diverse, cost-effective strategies that increase available supply in the lower basin while minimizing the impact on firm water customers.
8. A preference for a basin-wide approach to benefit both upstream and downstream interests will be given when pursuing water supply strategies.
9. LCRA will oppose any inter-basin transfer of surface water outside the Colorado River basin unless and except to the extent the transfer is consistent with LCRA's enabling legislation or other state law. Beyond existing commitments, LCRA will not plan for sales outside the basin unless and except to the extent it has secured water supplies to meet current and future in-basin demands.

#### **501.30 WATER CONSERVATION**

LCRA will meet or exceed state water conservation requirements and provide leadership in promoting the conservation of water. LCRA's commitment to conserving water will be achieved by implementing a variety of programs designed to encourage the conservation of water, including:

- Rigorous conservation requirements in rules and contracts
- Technical assistance and training
- Public education
- Incentives to customers
- Raw water rates or surcharges that encourage conservation
- Joint programs with customers and other stakeholders to encourage local initiative
- Programs to encourage the beneficial reuse and recycling of water

#### **501.40 ENVIRONMENTAL FLOWS**

LCRA is committed to maintaining, and where reasonably possible, improving fish, wildlife, and recreation resources in the river and bay system. LCRA should continue to be a leader in developing high quality science on environmental flows for the benefit of the lower Colorado River basin and comply with all state and federal requirements in the most efficient way possible. LCRA will provide water to help meet environmental flow needs in a manner that does not diminish or hamper its ability to meet current and future water demands of other beneficial users in the basin.

#### **501.50 WATER QUALITY PROTECTION**



LCRA will provide leadership in protecting water quality and, where reasonably possible, improving the quality of the surface and groundwater within the lower Colorado River watershed. LCRA will seek to protect against degradation of water quality and will support recreation, aquatic life, and water supply uses of the waters under its jurisdiction. LCRA will implement this goal through monitoring, assessment, advocacy, contracting, regulatory oversight, and reliance on the best available science, technology and innovation. LCRA will cooperate with other concerned public and private entities to help address issues of concern related to water quality within the lower Colorado River watershed, including groundwater. LCRA will implement high water quality protections for its own projects and facilities that manage stormwater runoff to the maximum extent practicable and, at a minimum, maintain and implement state and federal water quality standards.

## **501.60 WATER CONTRACTS AND RATES**

### **501.601 Water Contracts**

LCRA will develop reasonable rules for the consideration, issuance, and administration of raw water contracts. Such rules should address requirements for water conservation, drought contingency, inter-basin transfers, water quality impacts, and other requirements necessary for the fair and appropriate administration of water contracts. The rules should be updated from time to time to reflect changes to Board policy, applicable law, or other business needs. Any such rules adopted by the Board are incorporated into this Policy by reference as if set forth fully in this Policy. LCRA staff shall develop standard form raw water contracts consistent with Board policies and rules.

### **501.602 Water Rates**

LCRA's rates will be just and reasonable, not unduly discriminatory, and set to fully recover LCRA's costs to control, store, preserve, conserve, use, plan, develop, manage, distribute and sell the water supplies under its jurisdiction, consistent with state law. The rates will allow LCRA to be self-supporting in providing these services and provide for a stable and predictable flow of revenue.

### **501.603 Board Consideration and Public Input**

Implementation of new rates will be carried out within a time frame that attempts to minimize adverse impacts upon the customers of LCRA. All contract rules and rates will be presented to the LCRA Board of Directors for approval, and the public, including all water customers, will be afforded an opportunity to comment on such actions prior to the Board's consideration for approval.

## **501.70 LOWERING LCRA-OPERATED LAKES**

The General Manager may authorize the lowering of Inks Lake, Lake LBJ, Lake Marble Falls, and Lake Austin only if such lowerings will not interfere with LCRA's essential operations, adversely impact aquatic habitat, or result in any unrecovered losses related to water supply and are otherwise consistent with LCRA's water rights and existing contracts and leases. Further, such lowerings shall not result in any unrecovered losses related to hydrogeneration revenues for

any lowering of Lake Austin or any lowering of Inks Lake, Lake LBJ, or Lake Marble Falls that occurs with a frequency of more than once every four years.

**501.80            AUTHORITY**

Texas Water Code, Chapters 11 and 12; Texas Special District Local Laws Code §§ 8503.001, 8503.004, 8503.011, 8503.012, 8503.013, 8503.028, 8503.029, and 8503.030.

**EFFECTIVE:** December 15, 2010.